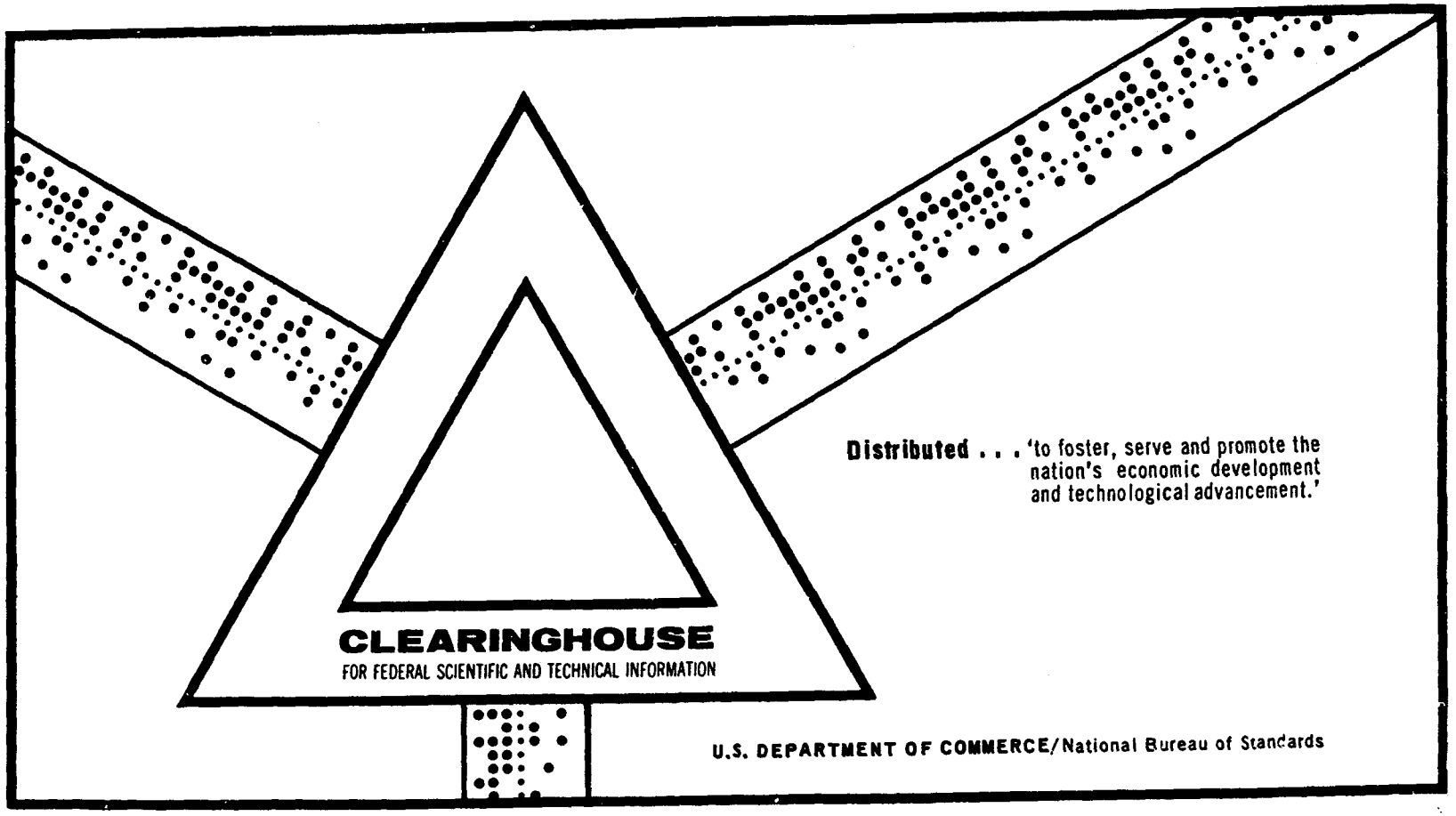
CLIMATE OF LAOS

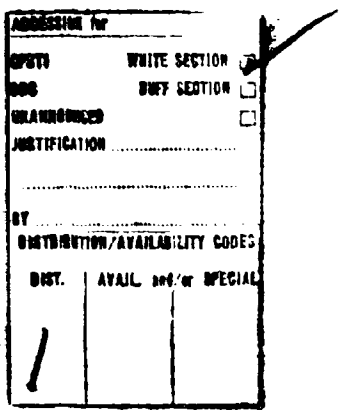
Weather Wing (1st)
APO San Francisco, California

October 1969



CLIMATE OF LAOS

1ST WEATHER WING
SPECIAL STUDY 105-14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DEPARTMENT OF THE AIR FORCE
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APO San Francisco 96553

PREFACE October 1969

1. 1st Weather Wing Special Study 105-14, "Climate of Laos" was prepared primarily as a planning aid to assist 1st Weather Wing units in providing basic climatic information for Laos.

2. Information contained in this publication is based on climatic averages and should not be construed as a forecast. It must be emphasized that actual weather conditions may deviate considerably from the mean values presented. For detailed operational planning support consult your local weather officer or Headquarters, 1st Weather Wing (1VC).

3. The period of record for data used in this publication ranges from 8 years (ceiling and visibility) to more than 40 years (precipitation). The number of available stations with usable data varies from 5 (ceiling and visibility) to 37 (precipitation). Primary sources of data were RUSSWO's, N-Summaries, NIS, and 1WWSS 105-11/1-12.

4. This study was prepared by Environmental Services (1VC), Aerospace Sciences Division, 1 Weather Wing, APO San Francisco 96553.

FOR THE COMMANDER

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Chief, Aerospace Sciences Division

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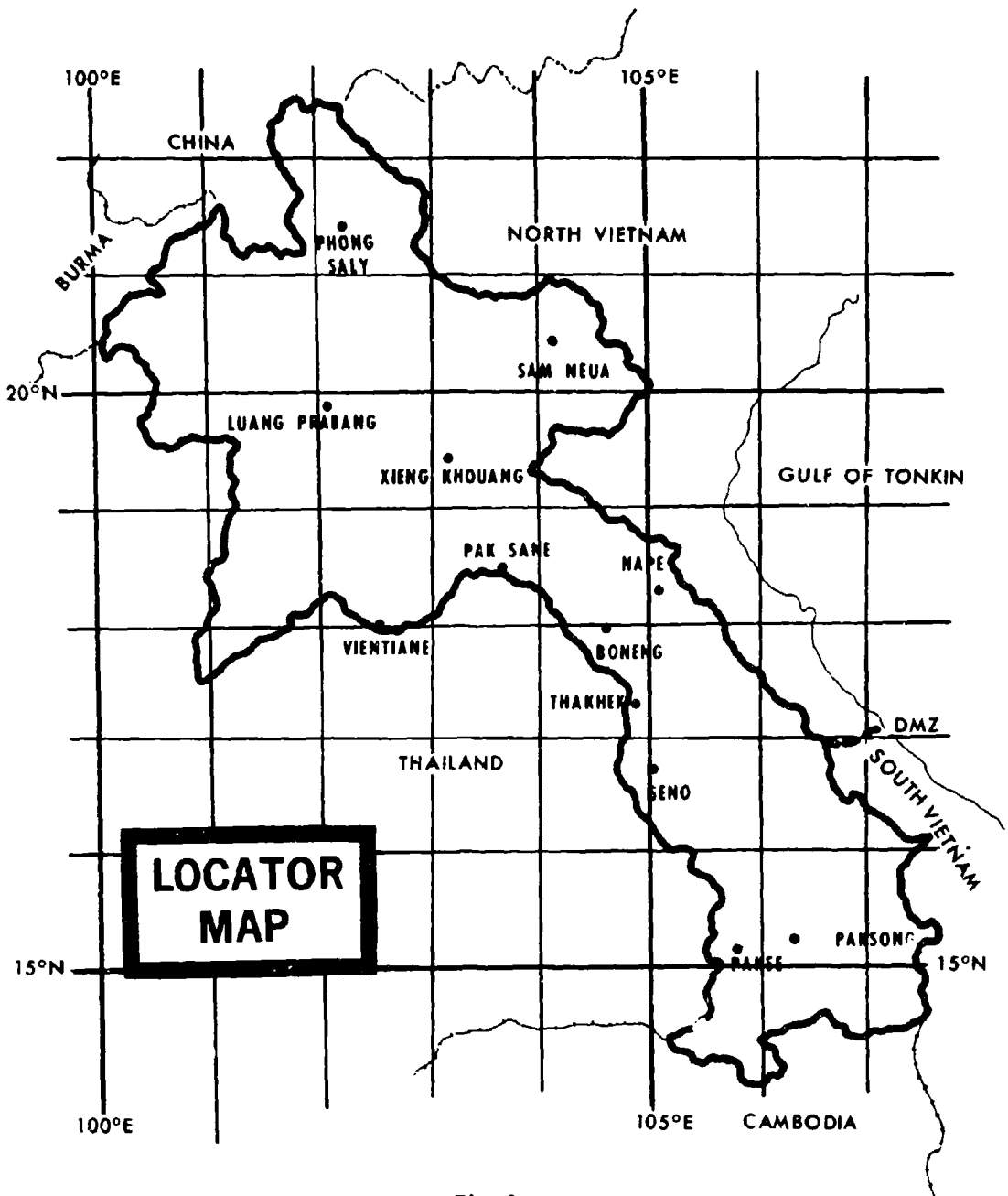
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Fig. 1

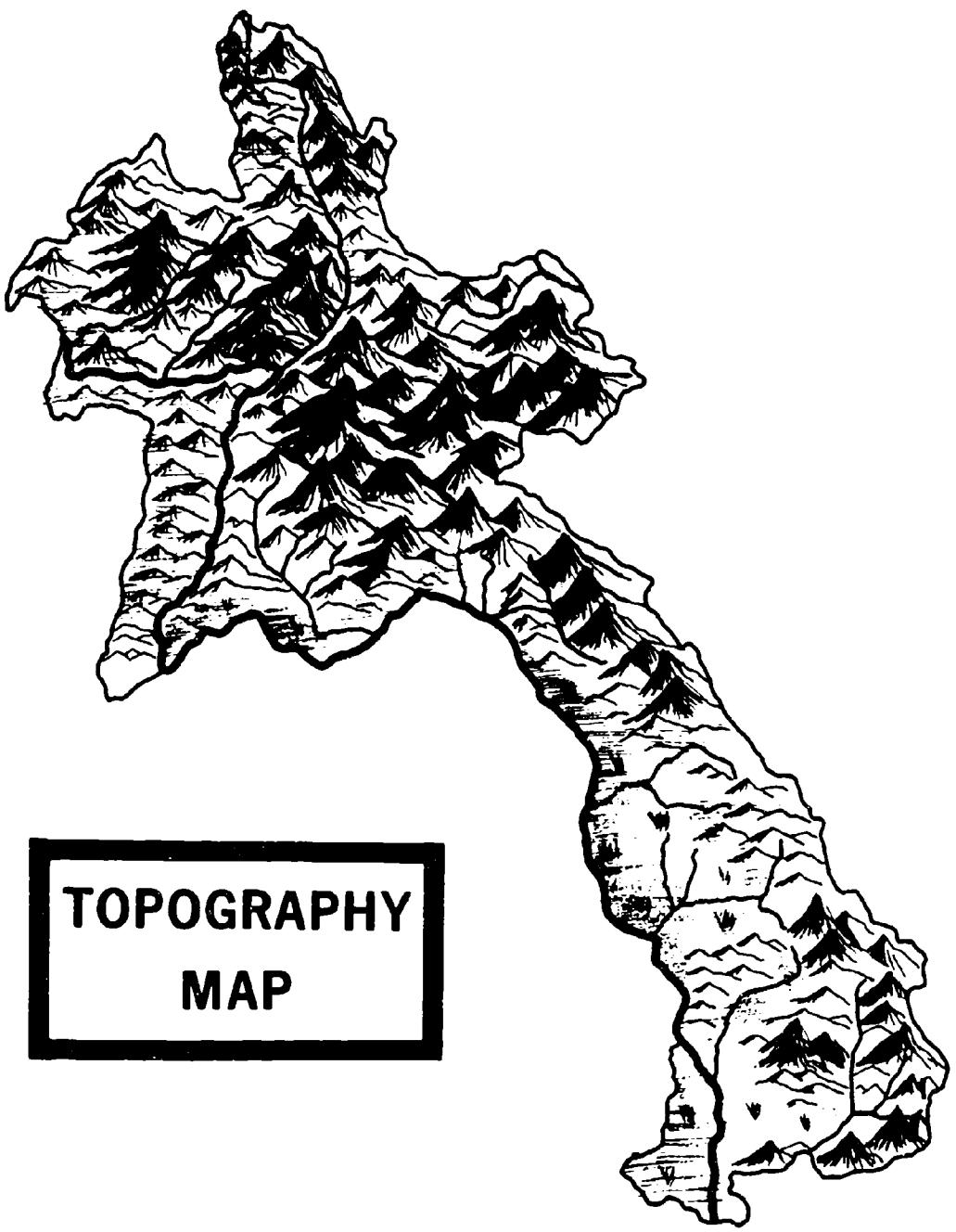


Fig. 2

PART 1

ANNUAL DISCUSSION

A. INTRODUCTION

1. Geography: Laos is one of the five major political entities comprising Southeast Asia. It extends from approximately 14°N to 23°N, consists primarily of mountainous or high plateau land and is landlocked. The northern half of the country is comprised of mountains and high plateaus that are cut by deep river valleys. The mountains, in general, are oriented northeast to southwest with several peaks extending above 7,000 ft. The highest, Phu Bia, extending to 9,242 ft. The southern half of Laos, frequently referred to as the panhandle, is composed of the Annam Range along the North and South Vietnamese borders, alluvial Plains that slope westward to the low-lying valley floor of the Mekong River, and the Bolovens Plateau just to the northwest of Attopeu. There are a number of deep passes through the Annam Range on the North Vietnamese border; two of the principal ones are the Deo Keo Hua and the Deo Mu Gia (see Fig. 2).

2. Climate: Laos has a monsoon climate characterized by rather distinct wet and dry seasons. In general, the southwest monsoon (mid-May through September) has heavy and frequent precipitation, high humidity, maximum cloudiness, relatively good visibility, and except at the higher elevations, high temperatures. In contrast, the northeast monsoon (November to mid-March) usually brings little precipitation, lower humidity, less cloudiness, frequent low visibility, and the coolest temperatures. These major seasons are separated by short transitional periods, each with characteristics of both monsoons. The climate is controlled primarily by the adjacent oceans and the large semi-permanent pressure systems of Asia which produce the large-scale monsoonal airflows. These currents bring greatly modified continental air from the Asian landmass during the northeast monsoon and warm, moist air from the tropical oceans during the southwest monsoon. Topography, latitudinal extent, and the nearby oceans produce marked areal climatic variations in all months. Migratory pressure systems also affect the climate, but their influence is relatively minor compared to that of other controls.

3. Temperature and Relative Humidity: During March, April and May, usually the hottest months, mean daily maximum temperatures range from the high 80's (°F) to the mid 90's, except at higher elevations where they are a few degrees cooler. In December, January and February, the coldest months, mean daily minimum temperatures range from the high 40's or low 50's in parts of the north and in the higher mountains to the high 60's in parts of the south. The relative humidity is highest in the early morning, with averages of about 75 to 95% and somewhat lower, about 45 to 75%, in the afternoon. In general, the lowest values of relative humidity occur most often during the northeast monsoon and spring.

4. Precipitation: Mean annual precipitation varies from about 25 in. in some sheltered sections to slightly more than 160 in. at exposed locations in the south. Although seasonal rainfall patterns vary throughout Laos, depending on exposure, most places report their heaviest precipitation in May through September or October. Monthly precipitation during the wet period generally varies from less than 5 in. at sheltered locations to more than 40 in. on exposed slopes, but most places record between 5 and 25 in. Over most of Laos the driest months are December through February. November and March are also dry at many places. During these dry periods, mean monthly amounts are less than 2 in and often less than 0.5 in. Snow may occur on the highest mountains in the extreme northern part of the country, but only on rare occasions. Thunderstorms occur throughout the country in all seasons, but most thunderstorms occur from April through October.

5. Cloudiness: Cloudiness is greatest from April through October with mostly clear or partly cloudy skies prevailing during the remaining months. Although ceilings and visibilities are generally adequate for air operations, there are some places where poor conditions, especially restricted visibility, may make low level air operations hazardous or impossible. In general, the poorest visibilities occur during the northeast monsoon, usually in the morning hours. Visibility is reduced primarily by haze, fog, smoke and rain, with considerable regional and diurnal variation.

6. Winds: Surface wind directions generally reflect the prevailing monsoonal airflow, but notable deviations are caused by the mountains and local topography. Winds are generally light ($< 10K$), with a high frequency of calm conditions prevailing over much of the area. However, strong winds occasionally occur, principally in association with thunderstorms or tropical storms. Typhoons influence this region, on an average, once a year, and usually during the period June through December. In most cases, the storms have abated to less than typhoon intensity prior to penetrating Laos.

B. REGIONAL DISCUSSION

Laos may be divided into two regions, mountains and lowlands. The mountain or highlands region includes most of the northern half of the country as well as the entire eastern border. The plains and lowlands region consists of the Mekong River and its principal tributaries. The regions have been determined primarily from differences in topography and partially from the distribution of rainfall and cloudiness. These divisions are not to be construed as climatic regions since no hard and fast boundaries are intended.

1. Mountain Region: The Mountain Region, covering much of the country, consists of hills, mountains and occasionally, high plateaus. The mountains, for the most part, are rugged and cut by deeply entrenched river valleys with a general north to south orientation. Elevations extend to slightly over 9,000 ft in the highest mountains located in the northern

half of the country. The climate of Laos varies greatly from place to place because of the effects of the mountainous terrain on the monsoonal flow. The largest variations occur in the precipitation pattern.

Temperatures vary greatly from place to place, depending on elevations and latitude. The highest temperatures occur during the spring, and the lowest occur during the northeast monsoon. The lowest temperatures, in all months, are recorded at the higher elevations in the north.

Precipitation over most of the region is heaviest during the southwest monsoon, but amounts vary considerably from place to place, depending on exposure to prevailing wind. Flash flooding during this season is common in the steep mountain valleys. Cloudiness follows a similar pattern and is generally greatest during the southwest monsoon and least during the northeast monsoon. Low ceilings and low visibilities are common, principally in the valleys during the northeast monsoon and on the higher, windward slopes at other times. Tropical storms occasionally bring torrential rains to Laos, especially to the mountains along the eastern border.

2. Plains and Lowlands Region: The plains and lowlands region comprises the Mekong River Basin in the western half of the Laotian Panhandle and near Vientiane. The region includes not only parts of the Mekong drainage basin, but also many of its Laotian tributaries. Terrain features vary from flat or rolling plains and rain forest to rice fields and marshlands. Elevations of the region are generally between 300 and 650 ft. The climate is similar to that experienced in the mountains.

Temperatures are high throughout the year but are generally highest during the spring, when extremes as high as 113F have occurred. Cloudiness, extensive during the southwest monsoon, is greatly reduced during the northeast monsoon, and skies are usually partly cloudy; clear days are frequent at some locations. Visibility is generally worse during this period because of haze, smoke and early morning fog.

Precipitation in this region, compared to the mountains, is somewhat less during the southwest monsoon and cloudiness is less during the northeast monsoon. Precipitation, however, is abundant during the southwest monsoon and is the major cause of occasional flooding in river basins. Tropical storms occasionally affect this region during the latter months of the year.

C. CLIMATIC CONDITIONS

The climate of Laos is controlled primarily by the position and strength of semi-permanent pressure systems and the resultant monsoonal circulation. Day-to-day weather conditions are affected to some degree

by migratory pressure systems and minor disturbances imbedded in the monsoonal flow, but these influences are relatively minor when compared to that of the primary controls. The mountainous terrain in this area, and in the neighboring countries, has a pronounced influence on the climate. Other important influences include the near-by continents, warm ocean waters and the latitudinal extent and position of the area.

1. General Circulation: The general monsoonal circulation over the area is the resultant flow between the semi-permanent pressure systems of Asia and the adjacent oceanic regions. The major systems affecting Laos are the Siberian High, the Asiatic Low, the Equatorial Low-Pressure Belt and the Southern Hemisphere Subtropical High-Pressure Belt. Seasonal changes in the position and strength of these cause a reversal of airflow, resulting in two distinct and opposing currents which identify the northeast and southwest monsoon seasons. Also, variations in the intensity of any of the systems in either season will result in day-to-day variations of the monsoonal flow and its effect on the area.

2. Seasonal Weather: Every year Laos experiences four relatively distinct climatic periods. When the Intertropical Convergence Zone (ICZ) is north of Laos, the southwest monsoon predominates. When it is south of Laos, the northeast monsoon predominates. During the transition periods between the monsoons, the ICZ is progressing through Laos; neither monsoon predominates, but some features of each are observed. The southwest monsoon, a major period, predominates from mid-May through September; the Autumn transition, a minor period, exists in October; the northeast monsoon, a major period, predominates from November through mid-March; and the Spring transition, a minor period, exists from mid-March through mid-May. The two major periods or seasons possess rather distinct climatic characteristics. The two minor periods possess more a mixture of both major season characteristics than any distinct features of their own. A discussion of the weather associated with the four periods follows:

a. Northeast Monsoon: From the end of October through mid-March, in a normal year, all of Laos is under the influence of the northeast monsoon. It is considered to be the dry season in Laos. Rainless months are a frequent occurrence at most locations and, in general, it is regarded as the "good weather" season. Although cloudless days are by no means the rule, there is, nonetheless, a marked decrease in general cloudiness. Clouds seldom achieve the vertical development of other seasons and thunderstorms become relatively rare. Temperatures and relative humidity, although high by temperate latitude standards, reach their annual minimum during this season. Minimum temperatures occur in December and January, and minimum humidities occur in March at most locations.

There is a significant increase in poor visibilities at this time of the year, particularly over northern Laos. This is brought about by an increase in morning fog, particularly in river valleys, and a drastic

increase in haze and smoke at other times of the day. Haze and smoke very frequently extend to altitudes of 10,000 ft and above.

b. Spring Transition: By the middle of March, the general circulation features primarily responsible for the northeast monsoon breakdown or dissappear entirely, and the country enters the spring transition season. This season occurs from mid-March through mid-May and is a period similar to the autumn transition in that it is somewhat unsettled, being under no definite monsoonal flow. In the early part of the period, the ICZ is moving northward but has not yet reached Laos. The flow of modified cooler polar air has already been cut off, and in this intervening period, temperatures reach their annual maximum, due to the overhead position of the sun and the relatively clear skies. Thunderstorm activity increases again and with it, an increase in precipitation is also observed. By mid-April a definite increase in cloudiness, humidity and precipitation is noted practically everywhere. As the ICZ moves northward over the country, the area once again experiences the unsettled conditions which are experienced during the period between the two monsoons. The northward progression is generally less definite than its southward march. In general, the latter part of this transition period is one of slightly decreasing temperatures though increasing humidity makes it seem hotter. Thunderstorm activity increases markedly as do precipitation amounts and frequency. Some of the severest thunderstorms of the year occur during this season. The increased precipitation does much to clean the atmosphere of the haze, dust and smoke of the northeast monsoon and early spring transition, thus visibilities show a significant improvement.

c. Southwest Monsoon: The southwest monsoon generally begins in mid-May and usually terminates by October, although the annual variation in the onset and cessation may vary as much as 2 weeks before or after these dates. It is the wet season in Laos and is characterized by an increase in humidity and a relatively drastic increase in cloudiness and precipitation. These changes are evident almost everywhere although they are most pronounced over the southern part of the country. Monthly precipitation amounts are from 5 to 10 times those of the northeast monsoon season at most locations. The heat becomes oppressive, primarily due to the high humidity. At most locations, thunderstorms are a daily occurrence. They occur primarily in the afternoon or early evening and occasionally persist through the night, particularly along the Mekong River Valley. This monsoon is, due to the almost daily heavy precipitation, a season of potential flooding along most rivers and flash flooding in narrow mountain valleys. There is, in conjunction with the increased precipitation, a pronounced increase in cloudiness, particularly convective type clouds. Although mornings may dawn relatively clear, clouds form at the 3,000 to 5,000 ft level rather rapidly by 1000 LST and frequently form ceilings at that altitude by early afternoon.

Visibilities are generally good during the southwest monsoon though they may be reduced in morning fog, particularly in river valleys, and momentarily in mid-afternoon thundershowers. Excellent visibilities are seldom observed because of the hazy nature of the tropical air.

d. Autumn Transition: In late September, the southwest monsoon begins retreating and Laos subsequently undergoes the shortest of the climatic periods. The autumn transition occurs during October. It is actually the period in which the ICZ traverses the country in its annual southward passage from China to the Equator and on into the southern hemisphere. Because the passage of the ICZ is seldom a firm and orderly progression, but rather a series of progressive pushes and retreats, characteristics of both monsoons may be present over the country at the same time. The relative timing of the last push causes the "onset" of the northeast monsoon to vary annually. It usually occurs, however, around the end of October. There is far less diurnal regularity to this period than there is in the other periods due to the "unsettling" influence of the ICZ and occasional intrusions of depressions wandering along the ICZ.

This relatively brief period is characterized primarily by a marked decrease in precipitation amounts together with a decrease, to a lesser degree, in thunderstorm and precipitation frequency, a decrease in general cloudiness and relative humidity and some slight increase in the frequency of fog. There is a slight decrease in average temperatures brought about primarily by a general drop in nighttime minimums. There is little change in daytime maximum temperatures. The northeast monsoonal flow eventually predominates by November. The yearly cycle is complete.

3. Air Masses: Basically, Laos is affected by only two air masses, the tropical maritime air of the southwest monsoon and the modified polar continental air of the northeast monsoon.

a. Northeast Monsoon: The northeast monsoon dominates Southeast Asia from November to mid-March. The air of the northeast monsoon originates as an extremely cold, dry air mass in its Siberian source region and undergoes great modification in its equatorward movement over the warm waters of the Pacific Ocean and South China Sea. This modified polar continental air mass affects all of SEA during the northeast monsoon. The eastern Vietnamese coast is exposed to this stable air mass which has gained considerable heat and moisture in the lower levels during its over-water trajectory. As this air is lifted over the Annam Range of Vietnam, it loses most of its moisture, resulting in generally clear to partly cloudy skies and scant rainfall on the leeward slopes in Laos. However, that part of the flow which has its trajectory entirely over land retains its dryness and is heated as it moves downslope west of the Annam Range into Laos.

b. Southwest Monsoon: The southwest monsoon dominates southeast Asia from mid-May to October. The air of the southwest monsoon originates

in part as a warm, dry, stable air mass in the semi-permanent high over Australia. It merges with the tropical maritime air from the Indian Ocean High as it moves northward to the equator. This flow is the southeast trade winds of the Southern Hemisphere, but upon entering the northern latitudes, it turns in a clockwise sense and approaches the area as a southwest flow. During passage over warm tropical waters, the air mass is rapidly modified by the addition of heat and moisture. It arrives over Southeast Asia as a very moist, unstable tropical air mass which produces extensive convective cloudiness, heavy rainshowers, and thunderstorms over most of the area, particularly windward slopes.

D. GEOGRAPHIC CONTROLS

1. Topography: The most important terrain feature affecting the climate is the Annam Range (Chaine Annamitique) running the length of the country. It occupies most of the northern half of Laos and the eastern half of the panhandle. The mountains lie almost perpendicular to the large scale monsoonal circulation and form a barrier to the prevailing flow. To a large degree, this accounts for the areal and seasonal variations in precipitation over Laos. During the southwest monsoon, the lift provided by these mountains augments the processes of convective instability to produce much cloudiness and heavy shower activity on the western slopes. During the northeast monsoon, the cloudiness and precipitation associated with the northeast flow generally occur on the eastern windward slopes, primarily in and over Vietnam. Most of the country, relatively free of orographically induced precipitation, experiences frequent days of clear skies and scant precipitation.

In addition to protecting most of the area against the adverse weather of the northeast monsoon, the mountains in the north also tend to shield the interior from the full effects of cold outbreaks from the Siberian High. Air reaching Laos from the north is warmed considerably in descending the mountains. This marked warming is evidenced by the moderate mean minimum temperatures in the lowlands.

Low-level and surface winds are influenced greatly by local topography. Low-level turbulence often accompanies winds blowing across the rugged mountainous terrain, and the channeling effect in the steeper valleys frequently causes local deviations in speed and direction that are significantly different from the mean monsoonal flow. In some cases, when valleys are perpendicular to the general flow, they provide a sheltered location ideal for the formation of fog. This fog is augmented by cold air drainage from the surrounding mountains. Mountain and valley winds produced by differential heating are also common in the mountainous parts of Laos.

One of the most beneficial effects of the mountains is the protection they provide to most of Laos against tropical storms and typhoons. During

the autumn transition, and early part of the northeast monsoon, Southeast Asia is subjected to intrusions of tropical storms and typhoons. When they move onshore along the Vietnamese coast, the Annam Range is instrumental in reducing and confining the more catastrophic effects. The force of the winds is substantially reduced by the mountainous terrain. Much of the moisture associated with these storms falls on the eastern slopes in torrential downpours.

2. Continental: The extremely large seasonal temperature and pressure reversals over the continents of Australia and Asia are instrumental in activating the large-scale monsoonal flow which affects Laos. Both Australia and Asia, particularly Asia, provide a land mass large enough to effect the buildup of large high pressure areas during their respective winters. It is the outflow of relatively cold dense air from these pressure centers that provides the impetus to the monsoonal flows. Conversely, during their respective summer seasons, large semi-permanent low pressure centers form over the two areas and provide a natural "funnel" into which the monsoonal flows channel, thereby adding further to the monsoonal strength.

3. Oceanic: The nearby ocean waters have important effects on the climate of this area. One is the pronounced large-scale modification of air masses reaching the area during the monsoon seasons. These air masses must pass over the nearby waters therefore acquiring heat and moisture. This moisture is the major source of the heavy rainfall associated with the southwest monsoon. The addition of heat to the polar air mass transforms the temperature characteristic from cold to warm prior to reaching Laos. In addition, the South China Sea and the Pacific Ocean are the principal spawning grounds of the tropical cyclones affecting the area.

4. Latitudinal: The latitudinal extent of this country goes from 14°N to 23°N latitude. Located within the tropics, much of the region is subjected to strong solar heating during most of the year. Consequently, the temperature variation from north to south is not as pronounced as it is in the more temperate regions of the world with the same latitudinal expanse.

E. SPECIAL PHENOMENA

1. Local Winds: Because much of Laos in mountainous, various types of locally produced winds occur. The orientation, height, configuration and location of the mountains determine the type as well as the extent of the wind. The two major types are the foehn and the jet-effect wind. A foehn is a dry, warm, gusty wind that occurs periodically when an air-stream is forced over a mountain range and rapidly descends the lee slopes. The air becomes comparatively warmer and drier before reaching the lowlands. They can be hot, dry and occasionally, strong, causing rapid rises in temperature and extreme evaporation along their path. Foehn winds over Laos could occur in any season but would be most likely over the eastern border area of the panhandle during the southwest monsoon. The jet-effect

wind is a local increase in wind speed caused by the channeling of air through the numerous and narrow mountain passes and canyons.

2. Floods and Droughts: Because of the heavy precipitation common to this area of the world, annual flooding along the larger rivers and their tributaries is a major concern in military operations. Massive overland movements may often be confined to the dry periods. High water and flooding tend to follow the period of maximum precipitation, occurring generally in May through October over most of the country. The regions most susceptible to flooding will be the lowland along the Mekong River and the lower courses of its major tributaries. Flash flooding is common in the relatively short, narrow streams in the mountains, especially when thunderstorms or tropical storms produce excessive rainfall in short periods of time. Flash floods rise and recede quickly and have greater destructive force than the floods in the lowlands where waters rise and recede more slowly. Droughts also occur, but very little information is available concerning their extend and severity. The analysis of available precipitation information, however, indicates that they probably occur most often in the lowlands but are not as frequent nor as severe as those in other parts of Asia.

3. Tornadoes, Hail and Duststorms: Most publications concerning the climate of this region fail to mention tornadoes. This fact, together with the lack of data, seems to indicate that they are rare. The larger thunderstorms of the transition seasons and the southwest monsoon, however, are capable of producing strong down-rush winds and tornadoes.

Information concerning the occurrence of hail is also limited, primarily because the available data have come from surface observations of this phenomenon as it reaches the ground. According to these data, hail is infrequent, occurring on only 1 or 2 days a year in the mountains and on less than 1 day a year at lower elevations. However, hail should be expected at flight levels in the vicinity of all large thunderstorms, especially those in mountainous regions.

Widespread duststorms are uncommon in Laos because of the lack of large dust producing regions such as deserts. However, during the dry months of the year, and occasionally in the wetter months when rainfall is not enough to offset the evaporative loss of ground moisture, dust may be raised in localized regions. Generally, dust of sufficient concentration to reduce visibility is confined to drained rice paddies, unpaved roads and areas of construction where the natural vegetation has been disturbed.

4. Extratropical Cyclones (Mid-Latitude Lows) and Fronts: Laos lies south of the normal cyclone track which crosses South China. Occasionally, however, lows move from west to east across the northern part of the country, primarily in January, February and March. Their passage temporarily disrupts the normal northeasterly flow and causes some cloudiness but little rainfall. Contrary to some tropical meteorology concepts,

frontal activity is observed in the northern half of the country where the remnants of weak fronts are relatively common during the northeast monsoon. These fronts, generally oriented east-west and triggered by surges of polar air from the Siberian High, move southward over all parts of Laos. Although the mountains serve to block much of the weather associated with the frontal surfaces, there is usually a slight increase in cloudiness and precipitation as one of these fronts passes over the country. Frequently, fronts stall over Laos where they remain until they dissipate or recede.

5. Tropical Cyclones: The frequency and effect of migratory tropical cyclones on the climate of Laos are minor from December through May, but become pronounced in the June through November period. During this period, tropical cyclones of varying intensities move westward from the South China Sea, causing local variations in winds, rainfall and cloudiness. From December through May, the period of minimum activity, most tropical storms and typhoons curve northward before reaching Laos. The period of maximum cyclonic activity usually begins in June over Southeast Asia and continues into December. During the first four months of this period, tropical storms and typhoons tend to cross the northern part of the South China Sea; many recurve into South China. In the latter months, the cyclonic tracks move south. In June through September, most tropical storms and typhoons enter or pass close enough to adversely affect North Vietnam and the extreme northern part of South Vietnam. Some of these move across the mountains into northern Laos before losing their strength. In October, the month of maximum activity, the main cyclone tracks execute a marked shift southward and concentrate on the southern part of Southeast Asia. During this month, tropical storms and typhoons also tend to move further inland before dissipating. Although some tropical storms and typhoons continue to move across North Vietnam into northern Laos, the majority sweep through South Vietnam into southern Laos and beyond into Thailand. Cyclonic activity is confined to the southern part of Southeast Asia in November and December. During these months, tropical storms and typhoons are generally weaker than those in previous months and tend to follow more erratic courses. South Vietnam bears the brunt of these cyclones in November and December, although some occasionally move further inland into southern Laos. According to international agreement, tropical cyclones with winds less than 35 kt are classified as tropical depressions, those with winds 35 to 64 kt are tropical storms and cyclones with winds 65 kt or greater are typhoons.

There are few data on the frequency or effect of tropical depressions over Laos. However, available information indicates that they are most likely to occur during the transitional seasons in conjunction with the migration of the ICZ and during the latter part of the year, when dissipating tropical storms or typhoons move westward over the Chaine Annamitique. In addition, depressions occasionally reach the country from the South China Sea during the northeast monsoon. Depressions are usually marked by a temporary disruption of the normal wind pattern and by an increase in cloudiness and precipitation along their tracks.

Typhoons and tropical storms are the most widespread and destructive of the migratory tropical cyclones affecting Southeast Asia. Most of these, approximately 80%, originate over the Pacific Ocean east of the Philippines and move westward through the South China Sea; the remainder generally form over the South China Sea.

Typhoons and tropical storms have similar characteristics, varying only in degree of severity and areal coverage. Typical wind speeds in typhoons affecting Southeast Asia are about 45 kt at 50 mi from the center and 65 kt or more at 30 mi from the center; in tropical storms, strong winds cover a smaller radius, with somewhat lower speeds. The damaging effects of these winds, which uproot trees and demolish flimsily constructed buildings, are generally confined to the coastal regions east of the Chaine Annamitique. When typhoons or strong tropical storms move across the mountains without appreciable weakening, even the interior regions suffer some wind damage. Although the accompanying winds contribute their share of destruction, they are generally not as damaging as the flooding. Torrential and usually widespread rainfall, especially in the mountains, floods river channels and lowlands and may wash out roads, communication lines and airfields.

The following table presents the number of tropical cyclones occurring over Laos during the period 1947 thru 1966. No occurrences were recorded over Laos in the months of December through May.

NUMBER OF TROPICAL CYCLONES OCCURRING OVER LAOS - 1947 - 1966

	Jun	Jul	Aug	Sep	Oct	Nov	Total
Tropical cyclones ($\geq$ 35 kt)	2	0	6	4	12	1	25
Typhoons* ($\geq$65 kt)	1	0	1	2	9	1	14

* These cyclones reached typhonic intensity sometime during their life cycle but may have degenerated to a lesser intensity before entering Laos.

Notes that the values for tropical cyclones with winds equal to or greater than 35 kt include typhoons, while those for typhoons include only the cyclones which attained winds equal to or greater than 65 kt sometime during their life cycle. The data rather clearly delineate the periods of maximum and minimum cyclonic activity.

6. Convergence Zones: In addition to tropical cyclones, the Intertropical Convergence Zone (ICZ) and other convergence lines, such as easterly waves, contribute to the deterioration of the weather in Laos. The ICZ, migrating seasonally across the equator within the Tropics, is a broad discontinuity zone tetween the trade winds of the Northern and Southern Hemispheres. In this part of the world, the position of the ICZ varies annually between about 10°S and 25°N latitude. In December through February, it is South

of Laos but by early May, begins passing over the country in its northward movement and migrates to or beyond the northern borders by mid-May or June. In October, it again moves southward through Laos.

As the ICZ migrates northward in the spring, there is a gradual increase in convective cloudiness and precipitation through the spring transition to the maximum activity of the southwest monsoon. However, during the autumn transition, the southward movement of the ICZ brings a more abrupt and substantial decrease in convective cloudiness and heavy shower activity. Within the ICZ, convergence of the opposing hemispheric wind systems is usually accompanied by frequent thunderstorms and heavy shower activity. The ICZ is, however, not a continuous band of convective activity, but one in which large regions of relatively poor weather alternate with small regions of good weather. The effects are most pronounced over the open water. Overland, the ICZ is much less distinct, but it may account for much of the adverse weather experienced in Laos during the transitional seasons.

Easterly waves occasionally affect Laos, principally during the latter months of the year and usually south of about 17°N. These waves, embedded in the easterly airstream, produce increased shower and thunderstorm activity during their passage. On occasion, easterly waves generate circulations which intensify and reach Southeast Asia as tropical storms or typhoons.

F. WEATHER ELEMENTS

1. Temperature: The surface temperature regime in Laos may strongly influence a wide variety of military operations. Personnel movement, operation of vehicles and mechanized equipment, and aircraft takeoffs and landings are especially affected. Because Laos is within the Tropics, the comfort of personnel may become a factor in the success or failure of an operation. Data for mean daily maximum and mean daily minimum temperatures are presented in Fig. 7a - 7l. These data show generally that over Laos, higher temperatures occur during the spring and lower temperatures occur in January, or on rare occasion, in December. The lowest mean daily minimum temperatures occur at the higher elevations in the northern part of the country during the northeast monsoon.

The northeast monsoon is the coldest season of the year. Afternoon temperatures are between 70 and 90F, depending on elevation, and living conditions are reasonably comfortable. Extremes of 104F, however, have been recorded at the lower elevations during this season. The lowest temperatures of the year are, at most locations, recorded in January when mean daily minimum temperatures are generally in the 50's; some highland locations report daily minimums in the 40's. Most places have recorded extreme minimum temperatures in the 30's or low 40's. Freezing temperatures have occurred, especially on the highest mountains. During the northeast monsoon, daily temperature ranges are somewhat greater in the mountains than in the lowlands, with some places reporting a range of 30 deg or more. The normal range is 20 to 25F.

The spring transition period is the hottest season of the year. In general, the highest mean daily maximum temperatures occur in the lowlands just before the onset of the rainy southwest monsoon. Mean daily maximum temperatures range from as low as the high 70's in the mountains to as high as 95F in the lowlands. At this time of the year, mean daily minimum temperatures generally range from 60 to 75F, although they are in the 50's at some of the higher locations. Although extreme maximum temperatures in excess of 100F have occurred in several months at some low elevations, temperatures at the higher elevations do not exceed the low 90's.

Temperatures are somewhat cooler during the southwest monsoon than the spring, due primarily to the increased cloudiness and precipitation, but still warmer than the northeast monsoon. Mean daily maximums range from 73 to 92F and daily minimums from 63 to 76F. The daily temperature range is only about 10 to 15 degrees at most locations. The temperature patterns of the fall transition period are quite similar to those of the southwest monsoon.

Days with temperatures between 90 and 100F occur quite frequently during several months, with a few of the low level locations recording these temperatures in more than 150 days annually. Days when the maximum temperatures exceeds 100F are most frequent in April; a few locations record this temperature on 5 to 10 days. During March and May, temperatures this high are reported occasionally, but they are rare during the rest of the year. Freezing temperatures are very infrequent. However, some of the highest mountain locations experience freezing temperatures on 1 or 2 days each year, usually in December through February.

2. Humidity: Fig. 8a - 8l present mean relative humidity (%) values for three times a day by month for several stations in Laos. The data show a rather uniformly high early morning humidity with only slight variations from month to month throughout Laos. Mean morning values range between about 75 and 95%, depending on location. There is a very slight tendency for lower morning humidity during the latter half of the northeast monsoon. In the afternoon, however, relative humidity throughout the country is appreciably lower than in the morning and seasonal variations are substantial. The afternoon humidity ranges between approximately 50 and 75%, with the lowest values occurring during the northeast monsoon and spring; the highest occurs during the southwest monsoon. In general, diurnal changes are greatest during the spring when variations may amount to 40 to 50%. They are least during the southwest monsoon when the variation is typically only 20%.

3. Precipitation: Mean annual precipitation varies widely over the country, ranging from as little as about 25 in. to almost 160 in. in the southern part of the panhandle (See Fig. 4). Seasonal variations are also quite large, with monthly amounts ranging from less than 1 in. per month at many locations during the northeast monsoon to more than 40 in. per month on some exposed slopes during the southwest monsoon (See

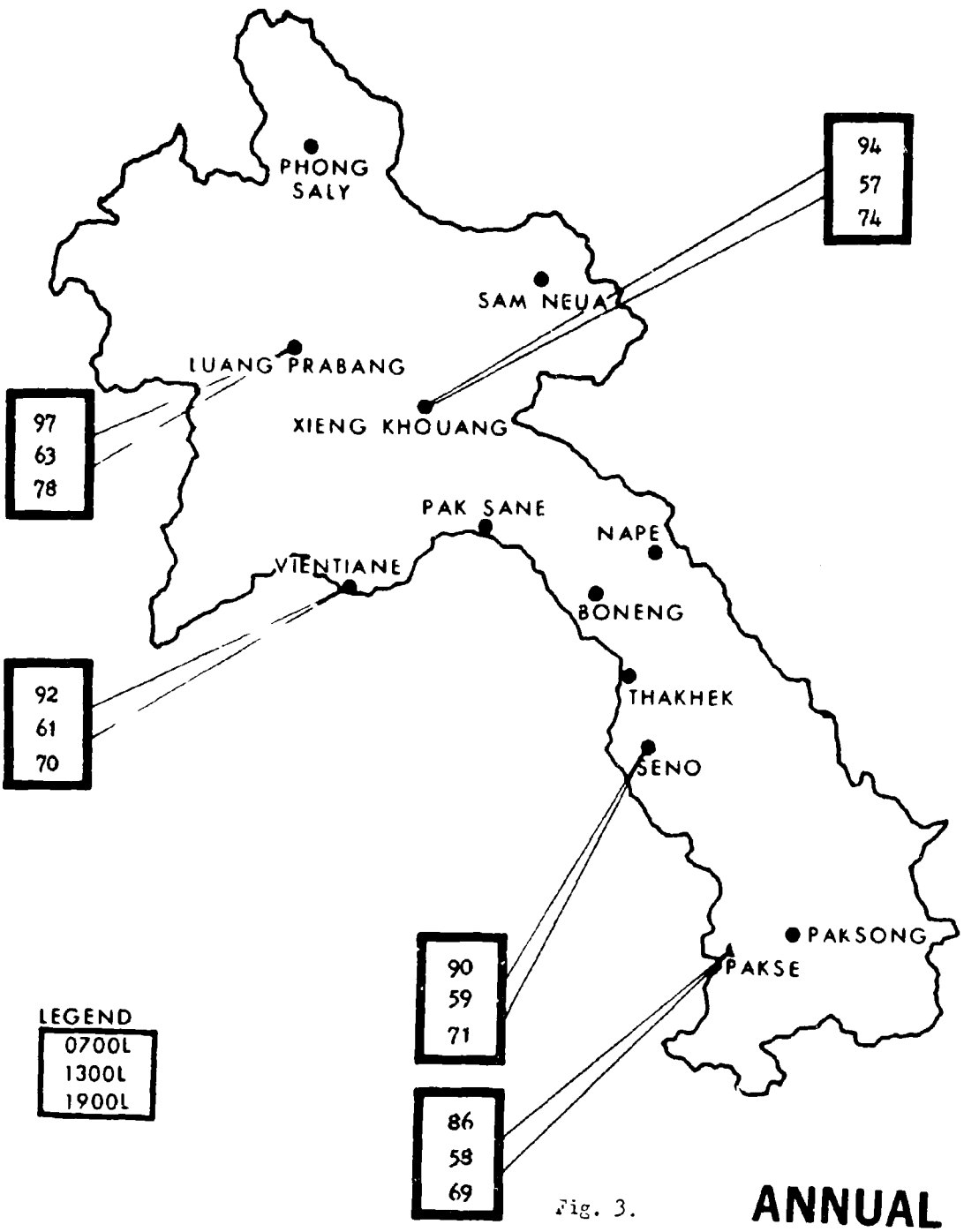

MEAN RELATIVE HUMIDITY (%)
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
PAKSE
94
57
74
97
63
78
92
61
70
90
59
71
86
58
69
LEGEND
0700L
1300L
1900L
ANNUAL

Fig. 3.

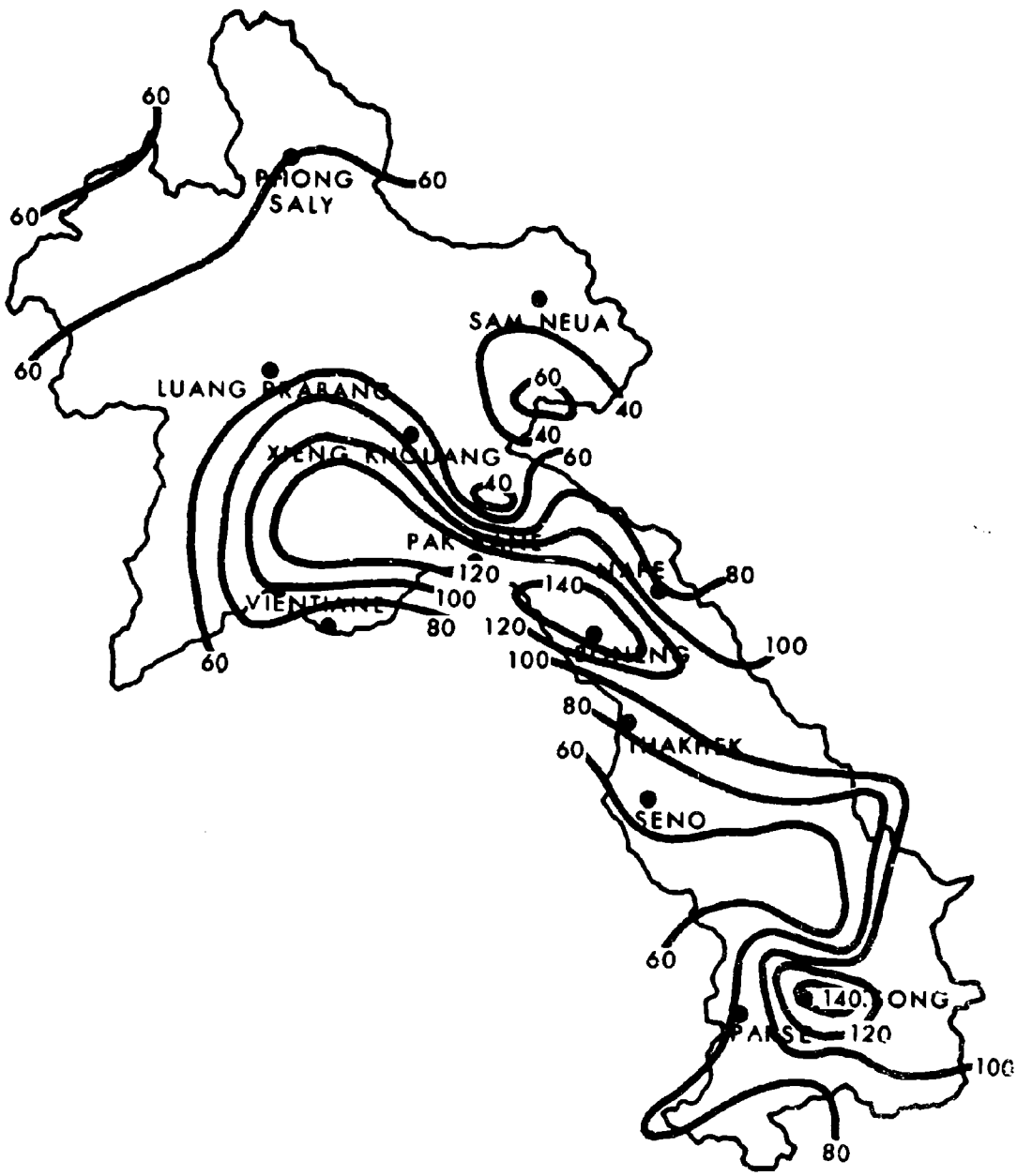

MEAN PRECIPITATION (in)
60
60
PHONG SALY
60
SAM NEUA
60
LUANG PRABANG
60
40
40
XIENG KHOUANG
60
40
120
140
80
100
VIENTIANE
80
120
100
60
100
80
60
SENO
60
140
120
100
80
ANNUAL

Fig. 4

MEAN NUMBER OF DAYS WITH PRECIPITATION

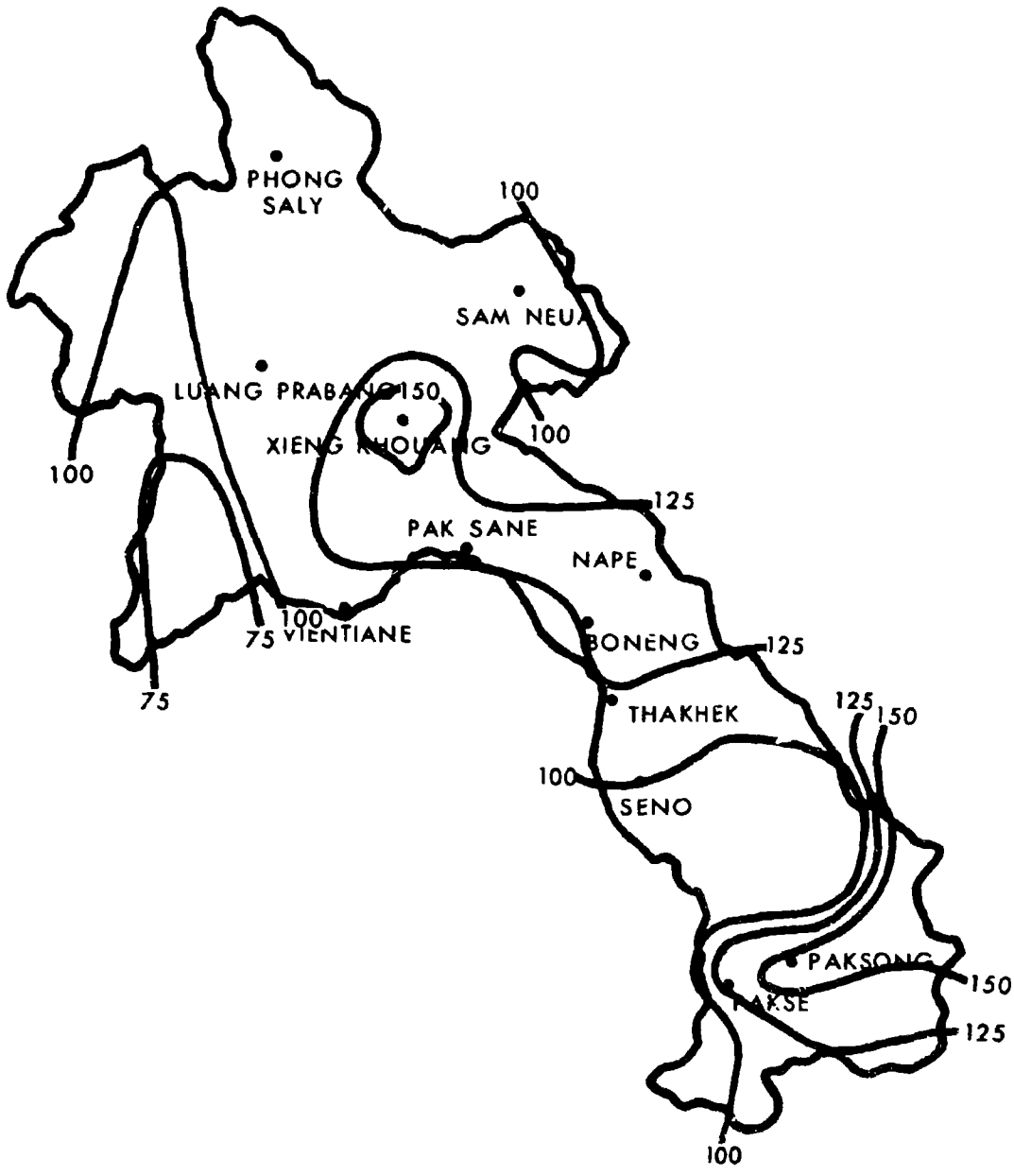


Fig. 5.

ANNUAL

PRECIPITATION and THUNDERSTORMS

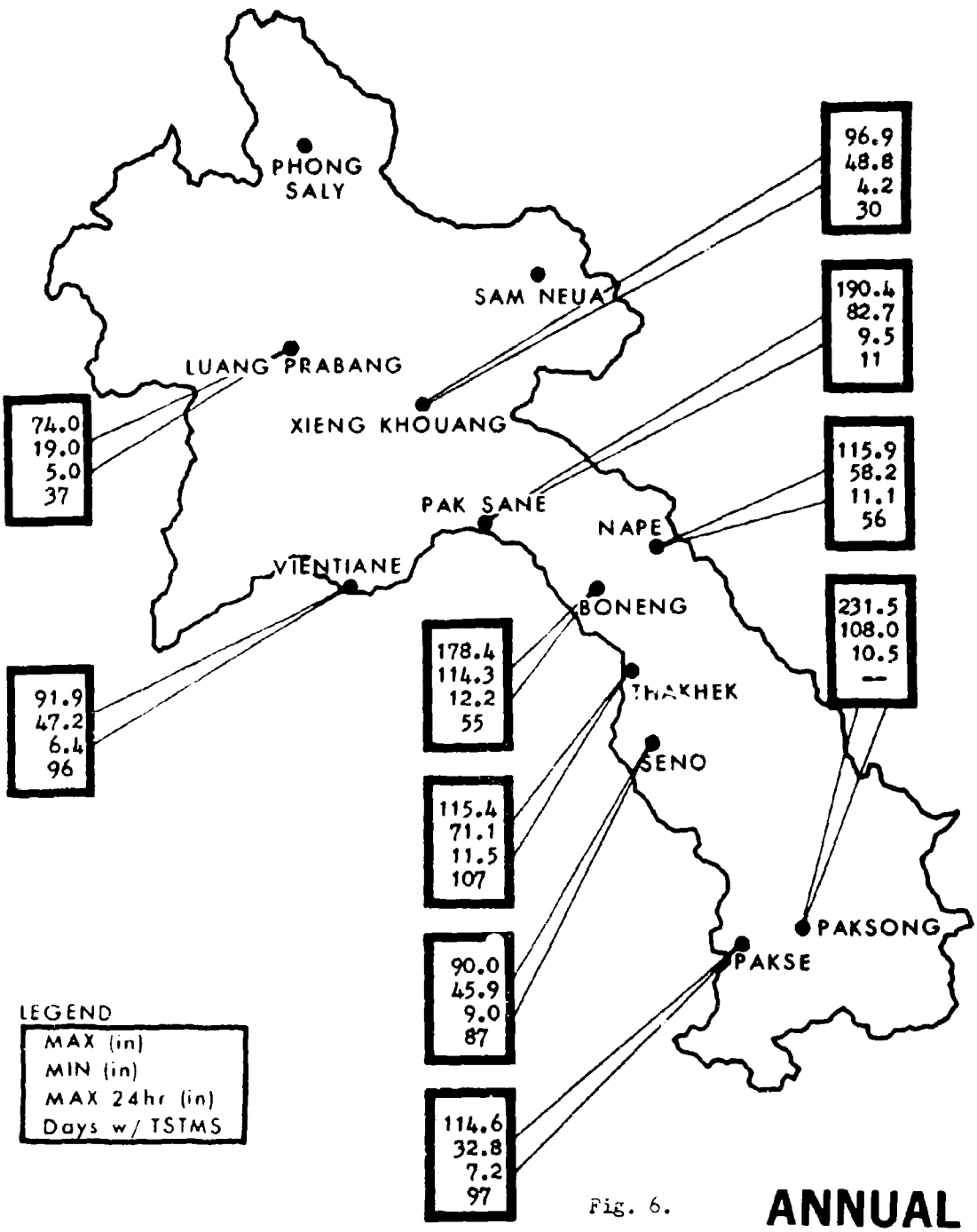


Fig. 6. **ANNUAL**

Fig. 10a - 101). Seasonal and regional variations of precipitation are largely caused by the mountain ranges within Southeast Asia. This orographic effect, resulting in abundant precipitation on the windward slopes and less precipitation on the lee slopes, is pronounced during both major seasons.

The northeast monsoon is the driest season of the year. The cool air approaching the coast of Southeast Asia is not deep enough to surmount the Chaine Annamitique and, as a result, most locations in Laos (leeward slopes) have very little precipitation. Much of the country is practically rainless during this period with mean monthly amounts usually less than 1 in. and often less than 0.5 in. Rainless months have been recorded almost everywhere. During this season, precipitation results primarily from isolated rainshowers and thunderstorms. Some larger storms have produced 24-hour precipitation values in excess of 5 in. Snow may occur on rare occasions on the highest mountains in the extreme northern parts of the country. The frequency and amounts of precipitation gradually increase through the spring transition period in late April and May. 24-hour amounts have exceeded 6 in. as a result of the large and severe thunderstorms of this transition period (See Figs 11a - 111).

The southwest monsoon is the wet season in Laos. Monthly amounts range from around 5 in. to more than 25 in. at several windward mountain locations. Some of the more exposed locations have a monthly value in excess of 40 in. during this rainy season. Daily maximum precipitation records show that most locations have recorded more than 5 to 10 in. in any one day. 24-hour precipitation extremes have exceeded 10 in at many lowland and mountain stations and some windward mountain locations have recorded maximum daily amounts in excess of 20 in. Minimum monthly precipitation values range from less than 0.5 in. to 22 in. Precipitation values decrease rapidly in October and by mid-November, Laos is again under the influence of the dry northeast monsoon. In most cases, mean precipitation is lightest in December through February. November and March are also comparatively dry at many locations throughout the country.

Because of the orographic effect on the moist airstreams over these regions, the annual number of days with measurable precipitation shows a large variation from place to place. Some of the more sheltered locations have only about 50 days with rain annually, whereas a few of the most exposed locations, especially those on the south and west slopes of the mountains, have as much as 180 days per year. Precipitation is most frequent in May through September when it is recorded on approximately 10 to 25 days per month at most locations. Rainy days are infrequent in December through February or March when 1 to 5 days per month with rain is the general rule (See Fig. 9a - 91).

4. Cloudiness: The amount and height above ground of clouds are very important in planning many types of air operations. This is especially true in mountainous regions. The terrain configuration in Laos causes

variations in cloudiness and ceiling. Ceilings in the valleys are frequently higher than those over the mountains, where clouds may obscure the ridges at times. This situation can be quite dangerous for low-flying or descending aircraft. Over Laos minimum cloudiness generally occurs in January through March, with the monthly frequencies averaging 35 to 40%. Cloud cover at this time of year has a slight tendency to be greater over the northern half of the country and along the ridge of the Chaine Annamitique and least over the Mekong Valley. Cloudiness usually starts increasing in spring as the northeast monsoonal flow begins to give way to the warmer air from the south.

With the onset of the southwest monsoon, there is usually a sharp increase in the amount of cloudiness. During this season, mean monthly cloudiness ranges from about 75 to 85%, occasionally as high as 90%. As the southwest monsoon weakens and the northeast monsoon begins to establish itself, cloudiness decreases markedly. This decrease usually takes place through October and November.

The diurnal variation of mean cloudiness is generally most pronounced during the latter part of the northeast monsoon. Data for those stations available in Laos show that the diurnal variation at this time is generally around 30%. Clouds are most prevalent during the day, usually in early afternoon and, in some cases, near sunrise. During the southwest monsoon, cloudiness is persistent night and day. Many places throughout the country have less than 10% diurnal variation during this season, especially in August and September.

The amount of cloudiness over these regions is reflected in the mean number of clear and cloudy days experienced over the country. Clear days are relatively infrequent except during the northeast monsoon season when they occur 10 to 20 days per month at most locations. Clear days are rare during the southwest monsoon season; most locations report only 1 to 2 days per month.

Cumulus type clouds predominate over Laos throughout the year. Cumulonimbus are frequent during the southwest monsoon, principally in May. A combination of cumulus and stratocumulus is common during the southwest monsoon. During the northeast monsoon, stratus clouds form in the early mornings, especially in the mountains and larger river valleys. Altocumulus clouds occur frequently as residual clouds of cumulonimbus clouds. Middle and high clouds occur, but the available data are not sufficient to indicate the frequency of occurrence.

Although low cloudiness is widespread, low ceilings, especially those hindering aircraft operations, are not as frequent as one might expect. Except in the more mountainous areas, ceilings are seldom less than 1,000 ft. They are generally most frequent during the southwest monsoon, but are reported on less than 5% of the observations at most locations. At higher elevations, ceilings less than 1,000 ft occur more often and the highest peaks are frequently cloud enshrouded. At some

places, this ceiling is the result of the formation of low stratus during the northeast monsoon, while other locations have this low ceiling most often during the southwest monsoon.

5. Thunderstorms, Turbulence and Hail: Thunderstorms are a prominent feature of the climate of Laos. They are a hazard to military operations in some regions because of their high frequency of occurrence and their severity. The frequency of days with thunderstorms for selected stations is presented in Fig. 6. An examination of these data points out the wide seasonal and areal variation in the occurrence of these storms. The mean annual number of days with thunderstorms ranges between about 11 and 110 with maximum activity occurring along the Mekong River and western slopes of the Chaine Annamitique in the panhandle. Thunderstorm occurrence is least frequent in the northeastern sections of the country.

Seasonally, thunderstorm activity throughout the country is at a minimum in November through February. Most localities experience less than 1 or 2 thunderstorm days monthly during this time. In March, thunderstorm activity increases practically everywhere except in the northernmost reaches of the country. In general, thunderstorm activity reaches a peak in May, when most locations for which data are available, report an average of 10 to 20 thunderstorm days for that month. Frequencies are only slightly lower in June through September. With the southward migration of the ICZ in October, thunderstorm frequency declines sharply (See Fig. 11a - 11l). Over Laos there is a pronounced diurnal variation in the occurrence of thunderstorms. This variation differs somewhat from place to place but changes little seasonally. Thunderstorms may occur at any hour of the day, but they are most common during the late afternoon and early evening and usually reach a peak between 1500 and 1700 hours LST. The time of minimum activity is between 0700 and 1000 hours LST. This diurnal variation is most pronounced in southern Laos where 60% of the thunderstorms occur between 1400 and 1800 hours LST.

The widespread convective activity, common in the warmer months of the year, produces much turbulence in the atmosphere over the country, particularly in the vicinity of cumulus and cumulonimbus clouds. Within thunderstorm areas, moderate-to-severe turbulence should always be anticipated; this turbulence often extends to great heights. Light-to-moderate turbulence should also be expected in the clear air immediately surrounding these clouds. As a general rule, the most severe thunderstorms occur during the spring and early part of the southwest monsoon, although equally intense storms may be encountered at other times, particularly over the mountains. Data concerning the intensity of thunderstorms and their vertical extent are scarce. However, the available information indicates that some storms may reach 50,000 to 60,000 ft and are frequently accompanied by heavy rainfall, gusty surface winds that are stronger than 30 kt, severe turbulence, considerable lightning, hail and possibly tornadoes. Data on hail are also extremely limited and tend

to underestimate the frequency because they reflect only the hail that reaches the ground and not that at flight levels. Consequently, caution demands the expectation of hail in the vicinity of all major cloud buildups.

Light, occasionally moderate, clear air turbulence is common over the lowlands during the absence of convective cloudiness. This type of turbulence is caused by surface heating and reaches its peak during the period of maximum heating in the afternoon. In all months, clear air turbulence should also be anticipated in the lower levels over the mountains, wherever the prevailing airflow is locally disrupted by terrain. Because most of Laos is mountainous, it seems logical to assume that turbulence may occasionally be caused by mountain waves. This phenomenon often occurs along and to the lee of the Chaine Annamitique. In addition, some local turbulence occurs in the mountains during periods of foehn winds.

At the higher levels, some clear air turbulence should be anticipated in the extreme northern part of the country in association with the jet stream. Light-to-moderate turbulence is also present in the shear zone aloft between the easterly and westerly flow.

6. Visibility: Because of the various factors which affect visibility in Laos, the regional, monthly and diurnal variations are quite large. Fig. 12a - 121 show the frequency of occurrence of visibility less than 1 mile and less than 5 miles by months for selected stations. The worst visibilities generally occur in the early morning during the northeast monsoon and in spring. Smoke, haze and fog are common throughout the year, although the heavy and frequent rains of the southwest monsoon tend to clear the air of smoke and haze particles. Dust occurs infrequently and is usually of a localized nature because there are no large dust-producing regions in or near the country.

Visibilities are frequently less than 5 miles at sunrise over large sections of the country, particularly during the northeast monsoon. Regionally, the mountains have the worst visibilities. At sunrise, they are below 1 mile about 25% of the time in some months of the northeast monsoon. Some locations record this condition as much as 45% of the time. Over most of the lowland region visibilities below 1 mile occur less than 5% of the time in the early morning hours and hardly at all at other times of the day. During the southwest monsoon, the visibility is much better at sunrise. Locations in the mountains for which data are available, show occurrences of visibility below 1 mile less than 5% of the time. During the late morning and early afternoon, low visibilities are fairly infrequent, and seldom, if ever, occurring at most locations.

There are large regional, seasonal and diurnal variations in the frequency of visibility less than 5 miles. In general, such visibilities are most likely at sunrise during the northeast monsoon and least likely in late morning or early afternoon during the southwest monsoon. However, some places in northern Laos such as Vientiane and Luang Prabang

rarely have good visibility at sunrise in any month of the year, whereas, at other locations such as Seno, visibility is seldom poor enough to hinder operations. Generally, visibility is at its best in late morning or early afternoon. However, even at this time of day some places report visibility below 5 miles more than 40% of the time during the northeast monsoon and as often as 10% during the southwest monsoon.

Smoke, haze, fog and rain are the chief factors restricting visibility throughout the country. Smoke and haze are common during the northeast monsoon, particularly in the northern half of the country. During the early morning hours, these restrictions are frequently recorded in conjunction with fog. Radiation fog is common especially in the mountains around large river basins. Such places are frequently clear at night, with very light surface winds. Fog also occurs when continous precipitation tends to saturate the air. However, this type of fog is not as frequent, nor does it restrict visibility as much as radiation fog. Precipitation itself does not restrict visibility to any great degree. Dust seldom occurs and then only as a local condition after a prolonged dry spell. Frequency of occurrence of various obstructions to vision by month for selected stations is presented in Fig. 13a - 13l.

7. Wind: Although the surface winds throughout Laos are influenced by a number of factors, they are primarily controlled by the two monsoonal systems. Therefore, surface winds are predominantly from a direction between north and east during the northeast monsoon and between south and west during the southwest monsoon. There are many variations from the generalized flow in Laos, particularly in the mountains where a channeling effect is inevitable; the wind directions depend upon the orientation of the mountain ranges.

Despite the many variations, the flow of both monsoons can be distinguished at most places. Mean wind speeds are light, particularly in the northern part of the country where calm conditions may exist on as many as 60% of the observations. Gale force winds (winds greater than 27 kt) occur infrequently over the area and are principally associated with thunderstorms or tropical cyclones. Most places record winds of gale force on less than 4 days per year; however, it is very likely that they may occur more often but are not recorded. Most localities in Laos have not recorded speed in excess of 40 kt. Although rare, strong winds have occurred most often during the northeast monsoon. However, since Laos is exposed to tropical storms and typhoons, stronger wind speeds have probably been experienced in other seasons but have gone unrecorded.

Wind directions and speeds are affected by local influences as well. Mountain and valley winds, a phenomenon diurnal in nature, are most prominent in Laos due to the terrain. The valley winds blow during the day as the warm air rises up the valley. The mountain winds blow at night, when the cool air sinks. Because of the rugged terrain throughout most of Laos, these winds probably occur frequently.

Upper wind data from Laos is very sparse, however, some generalized statements based on data observed over other parts of Southeast Asia can be made. During the northeast monsoon, easterly winds dominate most of the country at low levels. The layer of easterlies is very shallow, generally below 5,000 ft in the north, but extending to greater heights in the south. North of about 16°N latitude, westerly winds predominate above 10,000 ft. The relatively shallow airflow of the northeast monsoon rarely extends to this level. South of about 12°N, the tropical easterlies predominate at all levels up to about 60,000 ft. Between 12°N and 15°N, there is a transition zone, where a gradual change from the easterlies to westerlies occurs between 10,000 and 60,000 ft. Wind speeds are relatively light in the low levels but increases with height. Maximum wind speeds occur between about 35,000 and 45,000 ft in the easterlies. However, the upper-level easterly winds in the south are much lighter than the upper-level westerlies in the north. Wind speeds in excess of 100 kt rarely occur south of about 19°N latitude. North of 19°N, winds of 100 to 150 kt between 30,000 and 50,000 ft occur approximately 5 to 10% of the observations. Winds exceeding 150 kt are extremely rare.

During the southwest monsoon, westerly winds are predominant over most of the area up to about 20,000 ft. This is the level of transition from the low-level westerlies of the southwest monsoon to the tropical easterlies. At 20,000 ft, wind and directions are quire variable. Above 20,000 ft the tropical easterlies predominate to 100,000 ft or more. In the low-level westerlies, wind speeds are strongest in the south between about 5,000 and 10,000 ft, but are seldom greater than 90 kt. In the easterlies, speeds increase with height up to between 50,000 and 55,000 ft, then decrease up to about 70,000 ft. In the next 10,000 ft above this level, wind speeds again increase to some extent. However, data are relatively scarce above 80,000 ft. Easterly wind speeds of 100 to 150 kt occur on as many as 5% of the observations at about 55,000 ft in the central and northern sections. Speeds in excess of 100 kt are relatively rare elsewhere. Although scarce, available data above 100,000 ft show that easterly winds greater than 100 kt occur on as many as 10% of the observations.

Although the mean position of the westerly jet streams is north of the country during the northeast monsoon, daily fluctuations may occasionally bring it over northern Laos. Mean wind charts for the area show a maximum isotach of 80 kt extending as far south as 23°N in January. During the southwest monsoon, a center of maximum easterly winds occurs from about 18°N to 23°N latitude between 50,000 and 55,000 ft, but the winds are not as strong as the westerly winds of the northeast monsoon.

8. Aircraft Icing: Aircraft icing is generally limited to those clouds in which the temperature is between zero and -20C. Because Laos is within the Tropics, the icing level varies little regionally and seasonally. The type of icing encountered is largely dependent on drop size, rate of accretion and temperature. Factors which favor clear ice formation are temperatures from zero to -4C, rapid accretion and large drop size. These conditions are normally found in cumuliform clouds. Time

ice formation is favored by small droplet size as found in stratiform clouds, slow accretion and temperatures of about -10C or colder. However, at temperatures of -20C or colder, the moisture content of the air is usually too low for all but very light rime icing. Very little icing should be encountered during the northeast monsoon, because the widespread low cloudiness over the eastern borders of the country seldom extends above 10,000 ft. Portions of the country west of this are experiencing a minimum of cloudiness at this time. The most hazardous icing conditions are in towering cumulus clouds just before they reach the cumulonimbus stage. This situation is most often encountered in spring and during the southwest monsoon, when thunderstorms are most frequent. Upper air climatic data taken from other parts of Southeast Asia would indicate the greatest probability of clear icing over Laos lies between 15,000 and 18,000 ft in January. This zone lifts from January to June and by July lies between 18,000 and 21,000 ft. These are the approximate limits of the zero and -5C isotherms. Rime icing is most likely to be encountered between 21,000 and 27,000 ft in winter and 24,000 to 29,000 ft in summer.

PART II

MONTHLY DISCUSSION

A. JANUARY

1. Climatic Brief: During January the Siberian High reaches maximum intensity, consequently, the northeast monsoon developes to its fullest extent. As the cold dry air from the Siberian High flows southward, it is gradually heated by contact with the warmer China coast and waters of the South China Sea. This polar air merges over the water with warm moist tropical air from the western Pacific and arrives over Southeast Asia much warmer and more moist than when it left the continent. Compared with the May to October southwest monsoon, the northeast monsoon is relatively cool and dry.

During the northeast monsoon, most cloudiness and precipitation occur on the windward slopes of the Annam Range and along the east coast of North Vietnam and the Republic of Vietnam. By the time the northeast flow crosses the mountain chain and enters Laos, most of the cloud and precipitation producing moisture has been removed. Thus, the country enjoys relatively clear skies and little precipitation. Visibilities are generally good except for early morning valley fog.

January is one of the coolest months of the year exhibiting very little change from December. The relative humidity, although high, is decreasing slightly towards a springtime minimum.

2. Temperatures: Over most of Laos, January is one of the two coolest months of the year, differing very little from December. No temperature data are available for northern Laos; however, available data from neighboring countries indicate maximum temperatures in that region average 65 to 70F. Mean maximum temperatures in eastern Laos are between 70 and 75F, while those along the Thailand border average between 83 and 88F. The extreme January temperature for Laos is 103F at Luang Prabang. Mean daily minimum temperatures range from below 45F in the extreme north to above 60F in the extreme south. The extreme minimum on record is 28F at Xieng Khouang. (See Fig. 7a)

3. Relative Humidity: In January the relative humidity decreases somewhat towards an annual minimum in February and March. Despit this, humidity values are high, averaging 60 to 75% over most of the country. The highest humidity occurs during the early morning hours and after rainshowers; the lowest usually occurs during the afternoon. As with temperature, humidity can vary considerably over short distances. Values noted here are based on reporting stations only. (See Fig 8a)

4. Precipitation and Thunderstorms: January is a dry season month throughout the country. The majority of that precipitation which does occur is associated with afternoon convective showers or thunderstorms. Snowfall is possible at higher elevations in the northern mountains, but since cold temperatures are usually associated with dry air, the probability of snowfall is rather small. Hail occurs infrequently over Laos in January.

In general, there is little variability in January rainfall from one year to the next although some significant variations occur in the northern mountains. Precipitation is generally from light showers. Rainless Januaries are common everywhere.

The mean number of days with measurable precipitation is less than two days over all the country except along the Annam Range. Where these mountains are close to the Gulf of Tonkin, two to five rainy days can be expected.

Mean monthly precipitation amounts are less than 0.5 in. over all areas of the country except over windward mountain slopes in eastern Laos, where the mean rainfall may be in excess of one in. The highest recorded mean January rainfall is 0.7 in. at Phong Saly. Over most of Laos, the recorded maximum monthly precipitation is less than five inches. Values range from less than one in. in the extreme southwest to more than five in. over the northern mountains and parts of the Annam Range. The highest reported January rainfall for the country is 5.5 in. at Luang Prabang. High January rainfalls are also likely over the Annam Range. The minimum monthly precipitation is zero for all weather observing locations. Completely dry Januaries are frequent throughout the country except along portions of the Annam Range near the Gulf of Tonkin.

Maximum 24-hr precipitation varies from less than one in. over central portions of the country to more than 3 in. over northern mountains and parts of the Annam Range. Phong Saly has the highest reported one day rainfall of 5.0 in.

Thunderstorm activity is at a minimum over Laos during January. Most observing locations report one or less days per month with thunderstorms. They occur primarily during the afternoon or early evening. The incidence of thunderstorms may be somewhat higher over the mountain ridges, however no observational data are available from these areas. (See Fig 9a, 10a and 11a)

5. Cloudiness: January is the least cloudy month of the year over Laos. Cloudless skies exist over much of the country 60 to 70% of the time prior to 1100 LST.

River fog in northern valleys rises to become stratus ceilings generally below 1000 ft, before burning off by mid-morning. Convective clouds, with bases 2000 to 4000 ft, form over most areas during late morning hours but few afternoons have broken clouds. Mean cloudiness varies from less than 20% on the Thailand border north of Seno to about 60% along portions of the Vietnam border. The mean number of days with total cloud cover equal to or less than three-tenths varies from less than 10 days along the northern border with North Vietnam to 25 days along the Thailand border between Seno and Vientiane.

6. Visibility and Obstructions to Vision: Some of the best afternoon visibilities of the year occur over mountainous regions, while some of the worse afternoon visibilities occur in haze and smoke over plateau regions. Visibilities of less than 3 mi can be expected with early morning fog in the river valleys of the northern half of the country. These conditions rarely persist beyond 0900 LST. Haze and smoke restrict daytime visibilities over the Mekong River valley but low visibilities are infrequent. Surface visibilities are generally best between 0800 and 1100 LST. Fresh surges of the northeast monsoon usually improve visibilities in most regions temporarily, however, visibilities of greater than 12 mi are not common anywhere over the country. (See Fig. 12a and 13a)

7. Winds and Temperatures Aloft: A vertical wind distribution over Southeast Asia shows upper level wind veering through a full 360° between the surface and 70,000 ft. Although speeds are relatively light, significant increases in speed may be noted below 5,000 ft, and between 30,000 and 45,000 ft. Jet streams are rare but can move as far south as Laos with winds from the northwest at speeds over 50 kt.

The prevailing 2,000 ft flow over Laos in January is northeasterly. Local surface winds, both speed and direction, are influenced by local topography and may deviate significantly from the mean flow. When the Siberian high pressure is strong and shifted south, winds stronger than 10 kt occur. The northeast monsoonal flow extends upward to about 5,000 ft in the northern parts of Laos. With increasing altitude the winds veer towards a westerly direction. Over the Southern part of the country, the northeasterly flow extends vertically to about 8,000 ft. Between 10,000 and 20,000 ft winds become light and variable. Above 20,000 ft winds are more westerly and increase in strength to a maximum near 45,000 ft. Above 45,000 ft speeds decrease and at 70,000 ft there is a gradual reversal in direction with weak easterlies above this level.

The mean freezing level ranges from 12,000 ft in the north to 15,000 ft in the south; however, the actual height may vary as much as 3,000 ft from the mean. At 25,000 ft upper air temperatures are about -18C.

8. Combined Ceiling and Visibility: Ceilings and visibilities are poorest during the early morning hours, with visibility being the prime restrictant. The condition of $\geq$ 5000/5 occurs less than 10% of the time along the crests of the Chaine Annamatique and the Plaine des Jarres, and more than 90% in the basin around Seno. Although this pattern remains the same, there is a noticable improvement in conditions by mid afternoon over much of the country. At 1600 LST, conditions of $\geq$ 5000/5 occur close to 30% of the time even along the mountain crests and more than 70% of the time over much of the remainder of the country.

The frequency of $\geq$ 1000/2 1/2 is also at a minimum during the early morning hours and is as low as 30% over the Chaine Annamitique. By mid afternoon, considerable improvement normally takes place, particularly over the northern half of the country, where $\geq$ 1000/2 1/2 occurs between 70% and 90% of the time. (See Fig. 14a, 15a, 16a and 17a)

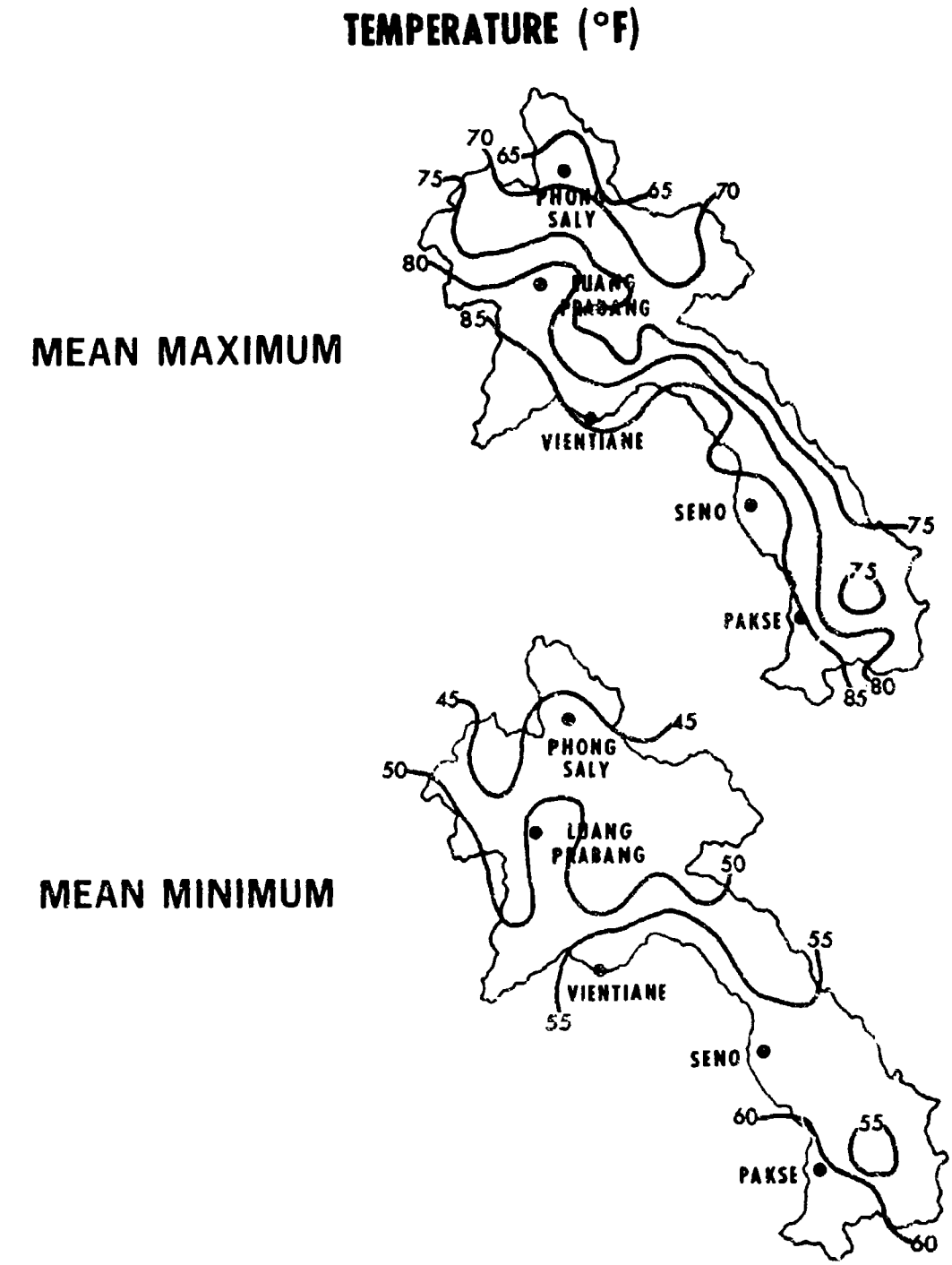

TEMPERATURE (°F)
MEAN MAXIMUM
70
65
75
PHONG SALY
65
70
80
LUANG PRABANG
85
VIENTIANE
SENO
75
75
PAKSE
85
80
MEAN MINIMUM
45
45
PHONG SALY
50
LUANG PRABANG
50
55
VIENTIANE
55
SENO
60
55
PAKSE
60
JAN

Fig. 7a.

MEAN RELATIVE HUMIDITY (%)

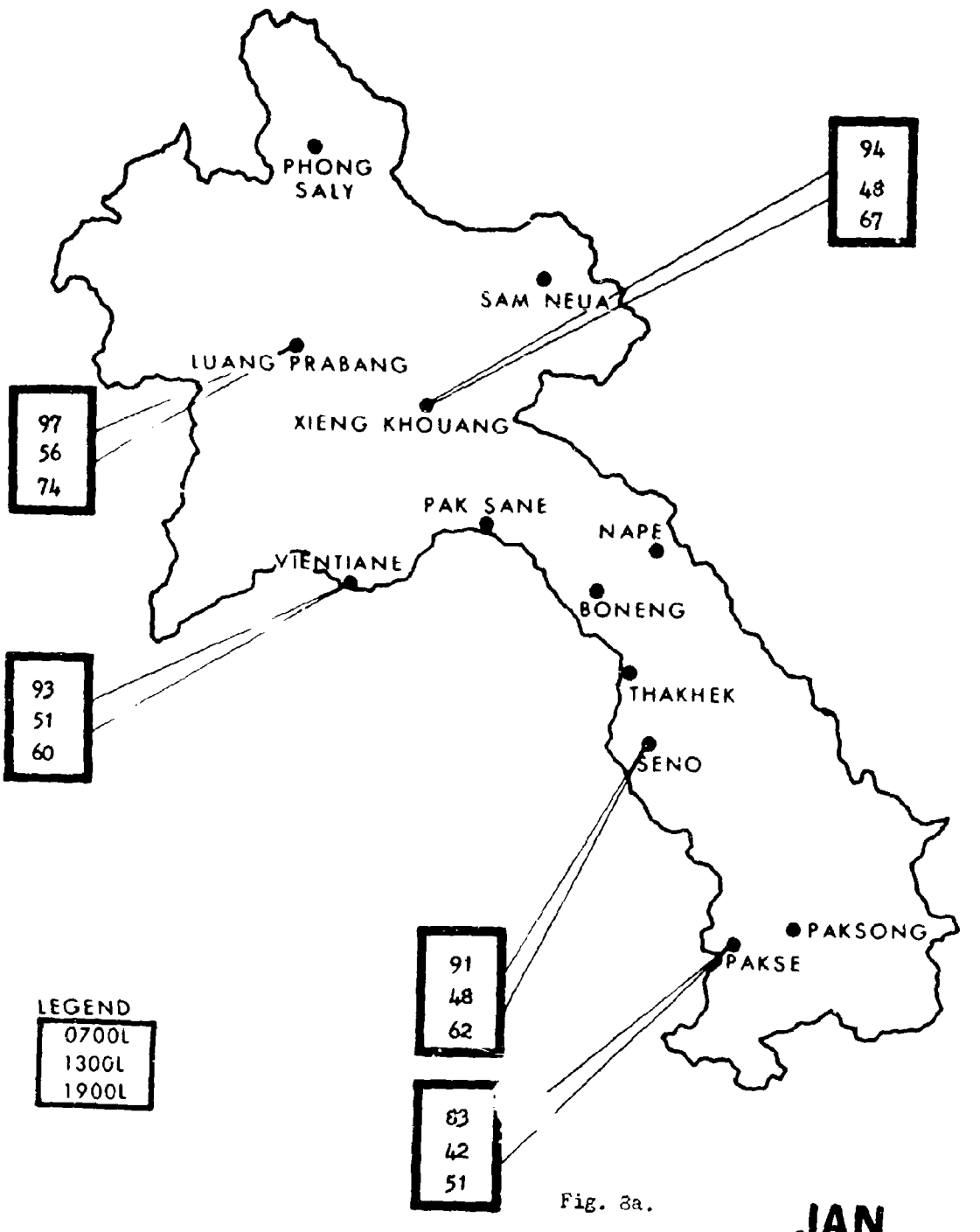


Fig. 8a.

JAN

MEAN NUMBER OF DAYS WITH PRECIPITATION

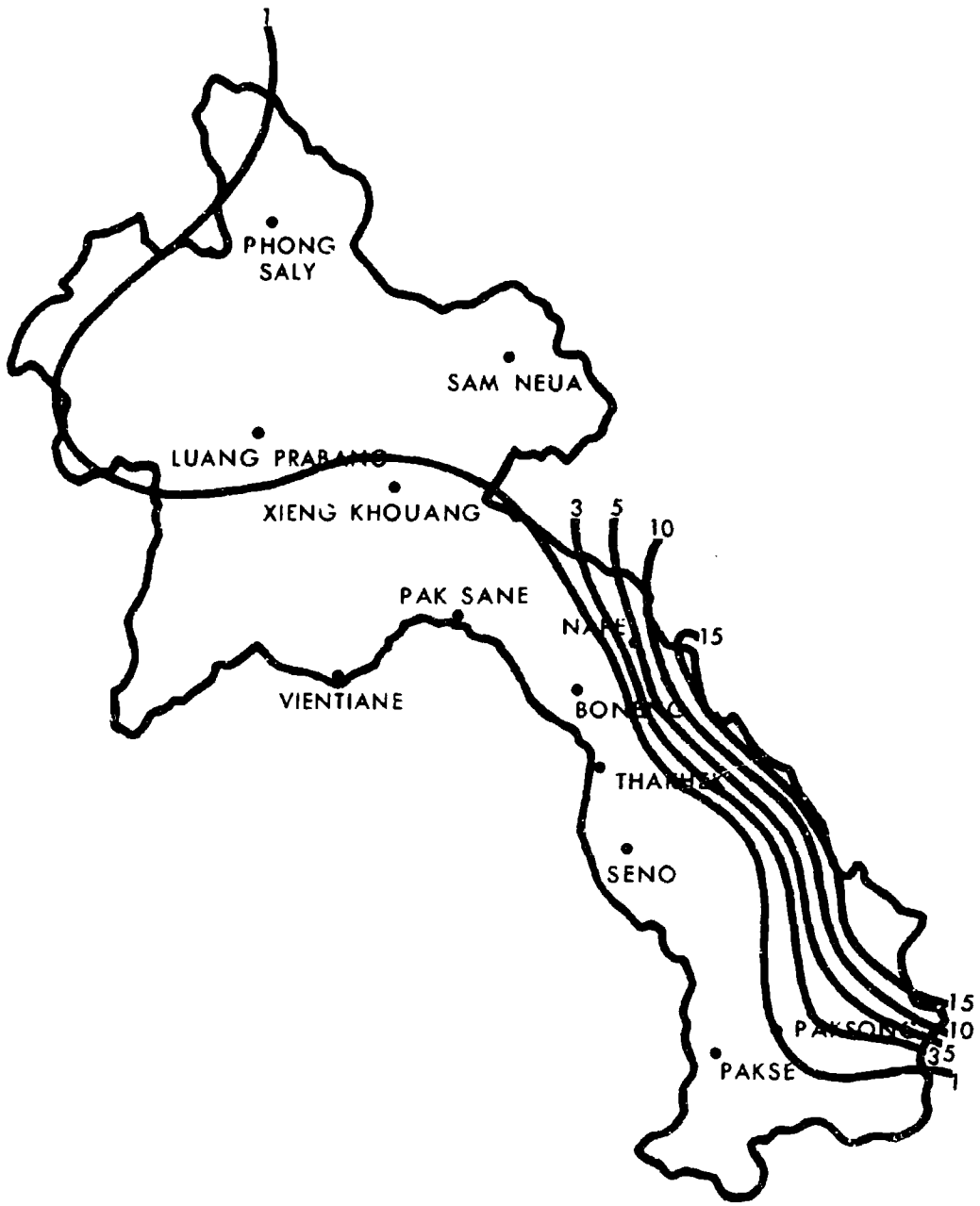


Fig. 9a.

JAN


MEAN PRECIPITATION (in)
0.5
PHONG SALY
SAM NEUA
0.5
LUANG PRABANG
XIENG KHOUANG
0.5
1
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
4
2
6
8
8
6
0.5
4
2
1
0.5
PAKSE
JAN

Fig. 10a

PRECIPITATION and THUNDERSTORMS

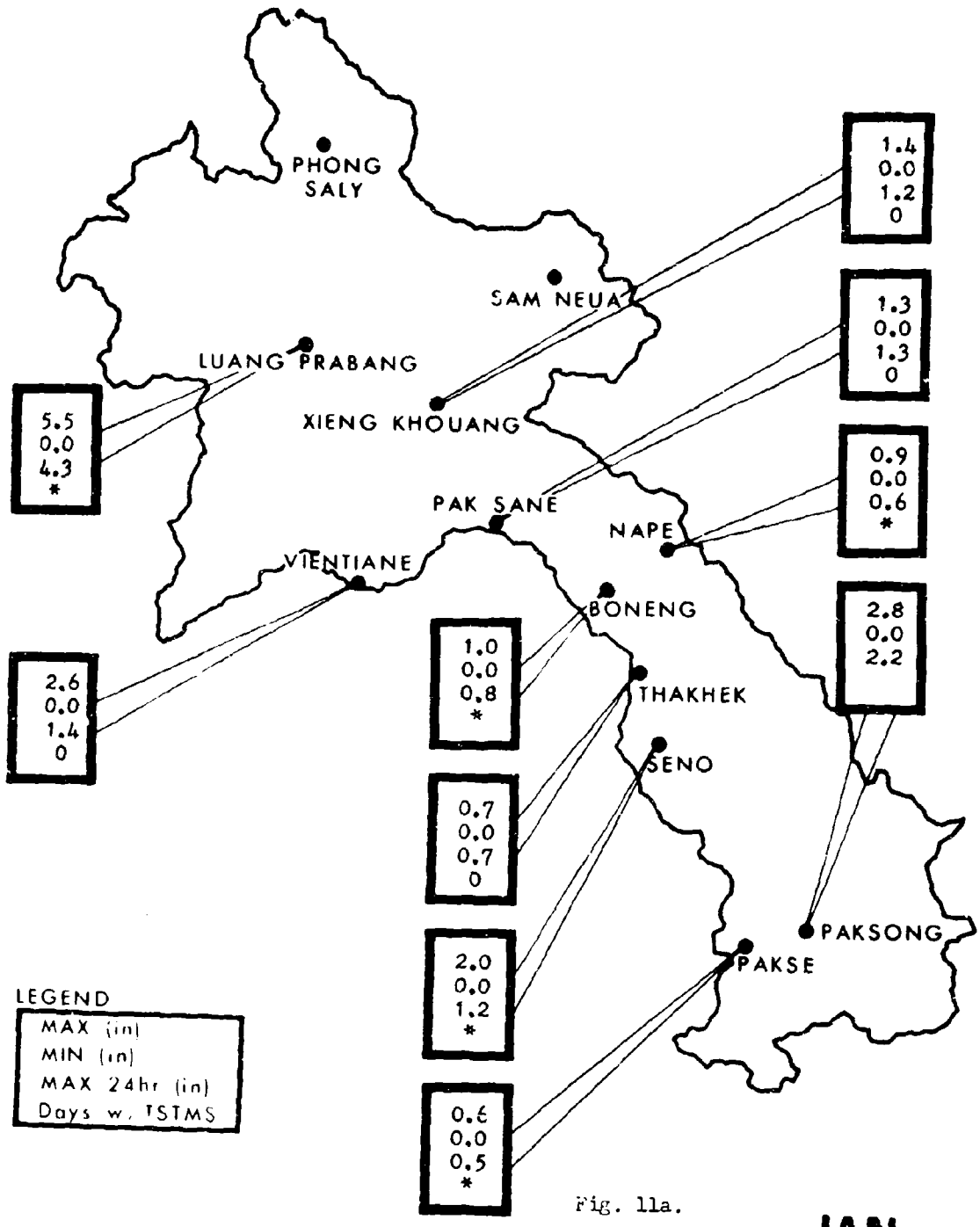


Fig. 11a.

JAN

VISIBILITY

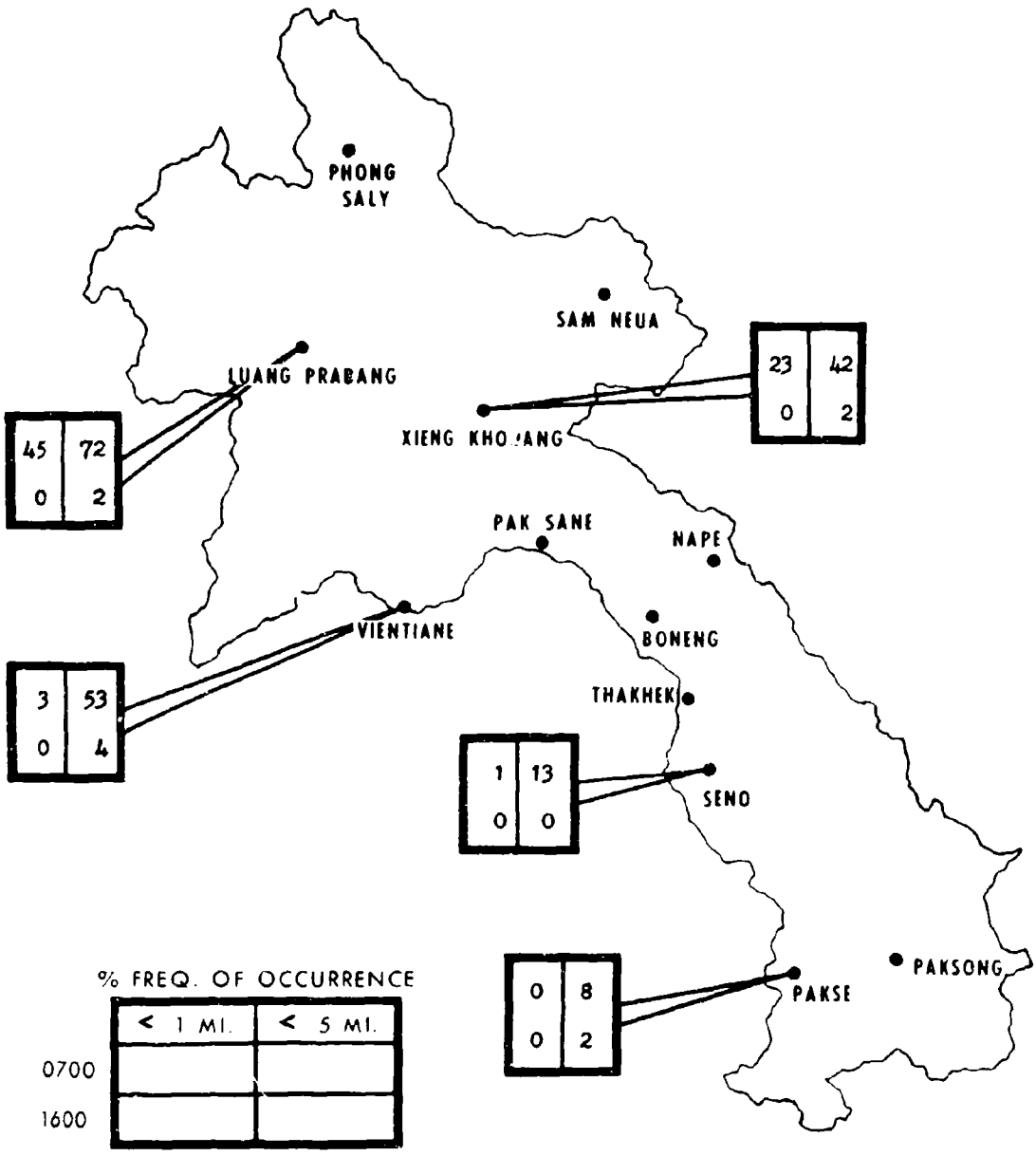


Fig. 12a.

JAN

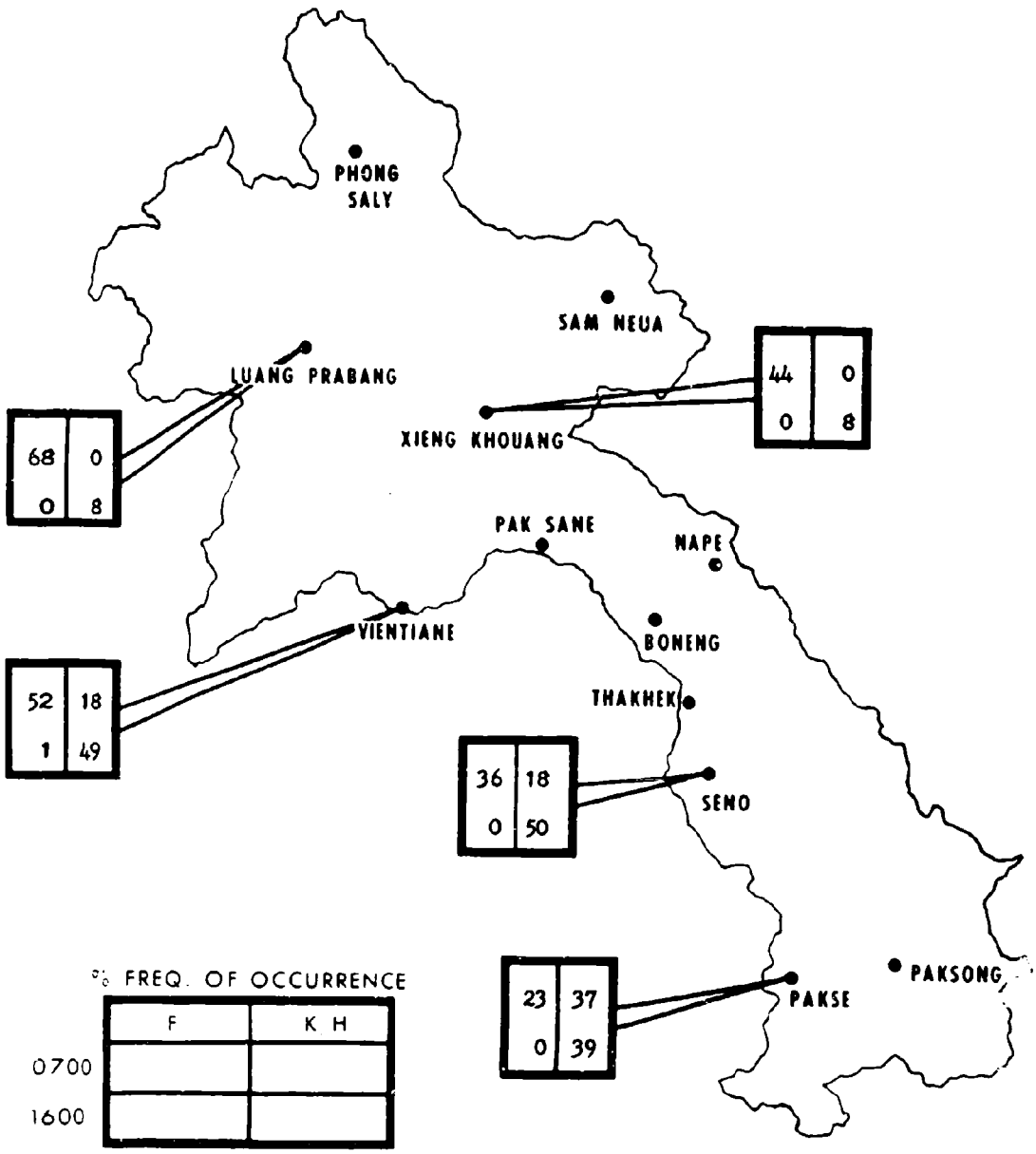

FOG-SMOKE/HAZE
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
PAKSE
68 0
0 8
44 0
0 8
52 18
1 49
36 18
0 50
23 37
0 39
% FREQ. OF OCCURRENCE
F
K H
0700
1600
JAN

Fig. 13a.

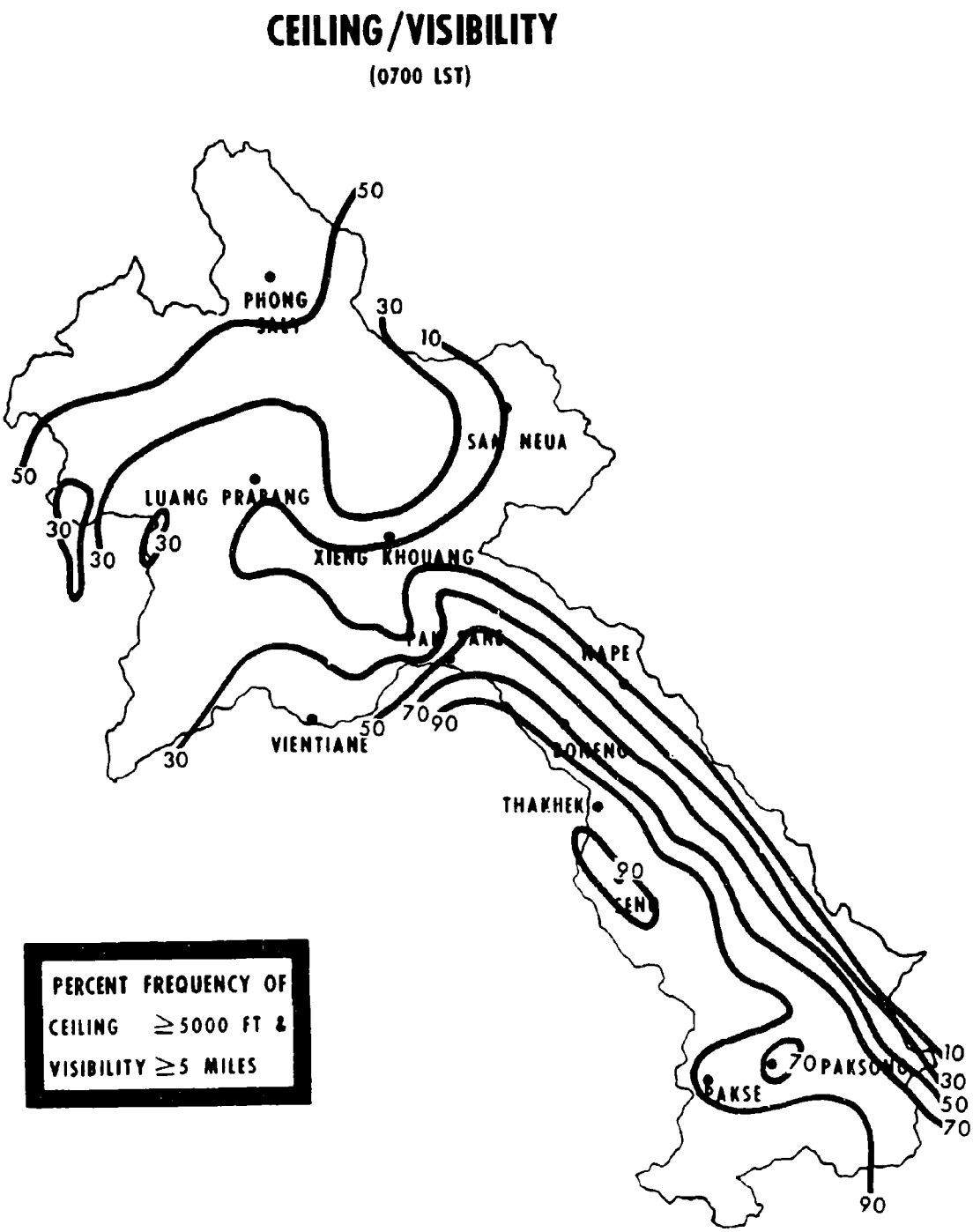

CEILING/VISIBILITY
(0700 LST)
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
VIENTIANE
THAKHEK
PAKSONG
PAKSE
50
30
10
50
30
30
30
30
50
70
90
90
10
30
50
70
90
PERCENT FREQUENCY OF
CEILING ≥5000 FT &
VISIBILITY ≥5 MILES
JAN

Fig. 11a

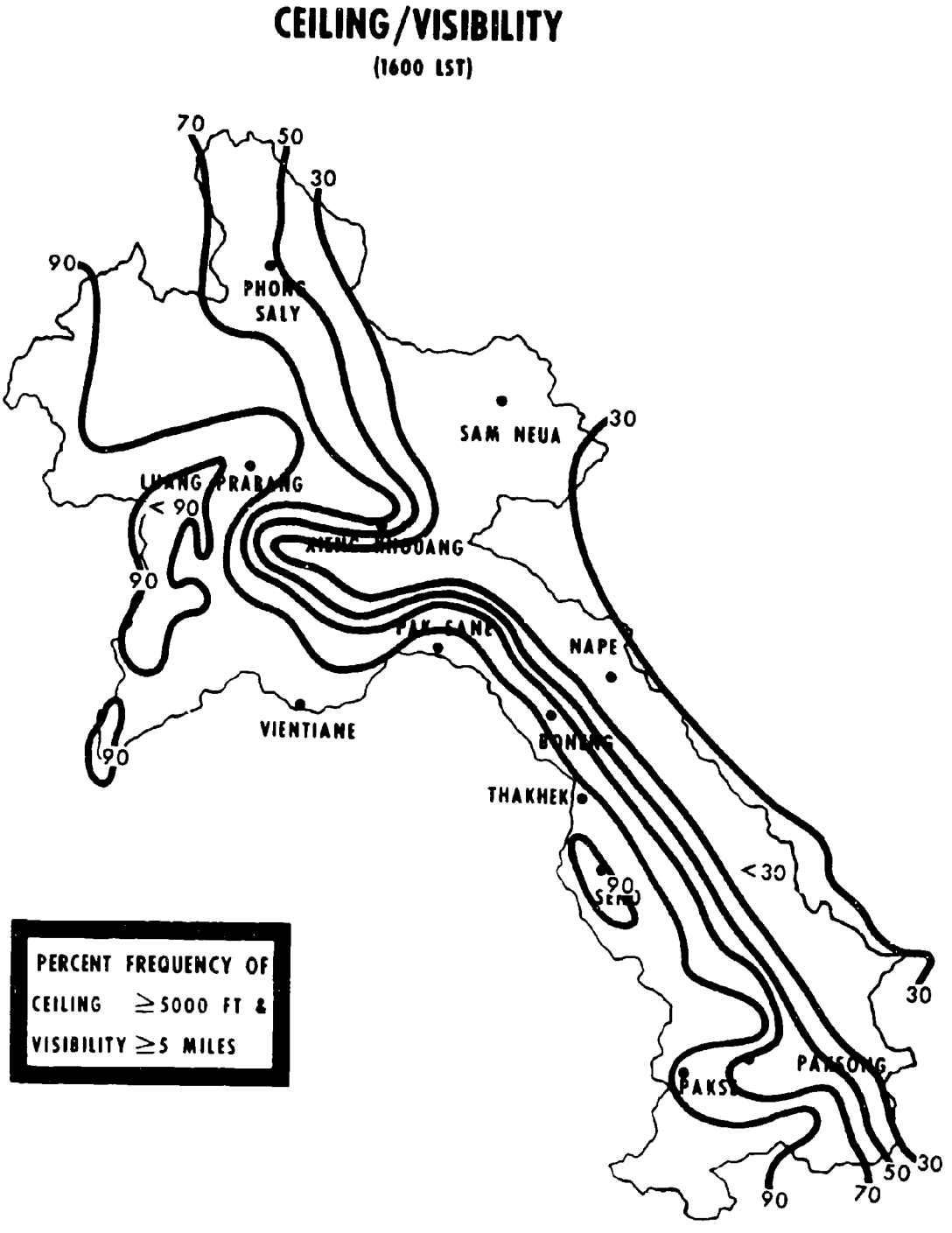

CEILING/VISIBILITY
(1600 LST)
70
50
30
90
PHONG SALY
SAM NEUA
30
LUANG PRABANG
< 90
90
PAK SANE
NAPE
VIENTIANE
90
THAKHEK
90
< 30
30
PAKSE
PAKSONG
50
30
90
70
PERCENT FREQUENCY OF
CEILING ≥5000 FT &
VISIBILITY ≥5 MILES
JAN

Fig.15a

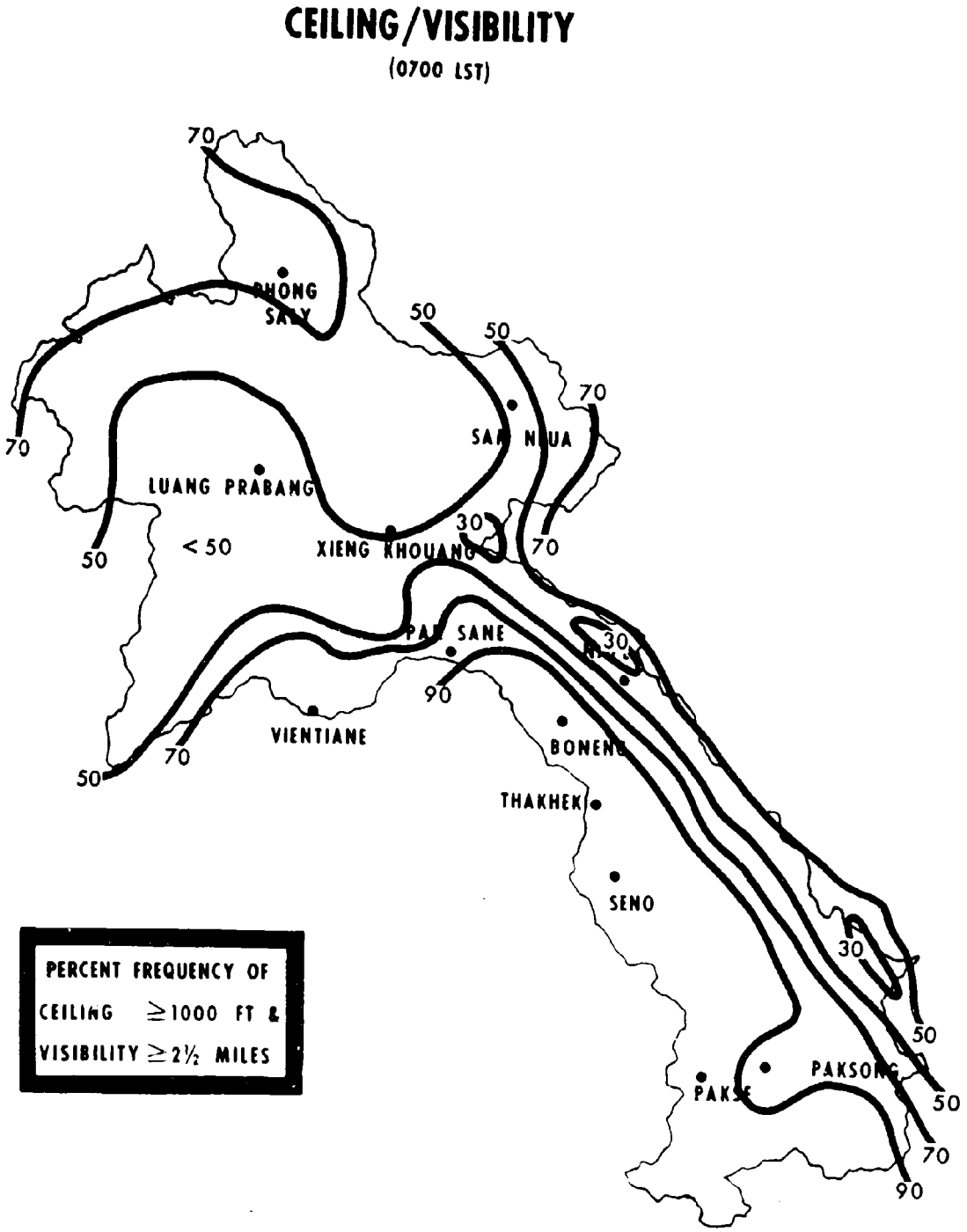

CEILING/VISIBILITY
(0700 LST)
70
PHONG SALY
50
50
70
SAM NEUA
70
LUANG PRABANG
50
< 50
XIENG KHOUANG
30
70
PAK SANE
30
90
VIENTIANE
70
50
BONENG
THAKHEK
SENO
30
50
PAKSONG
PAKSE
50
70
90
PERCENT FREQUENCY OF
CEILING ≥1000 FT &
VISIBILITY ≥2½ MILES
JAN

Fig. 16a

CEILING/VISIBILITY

(1600 LST)

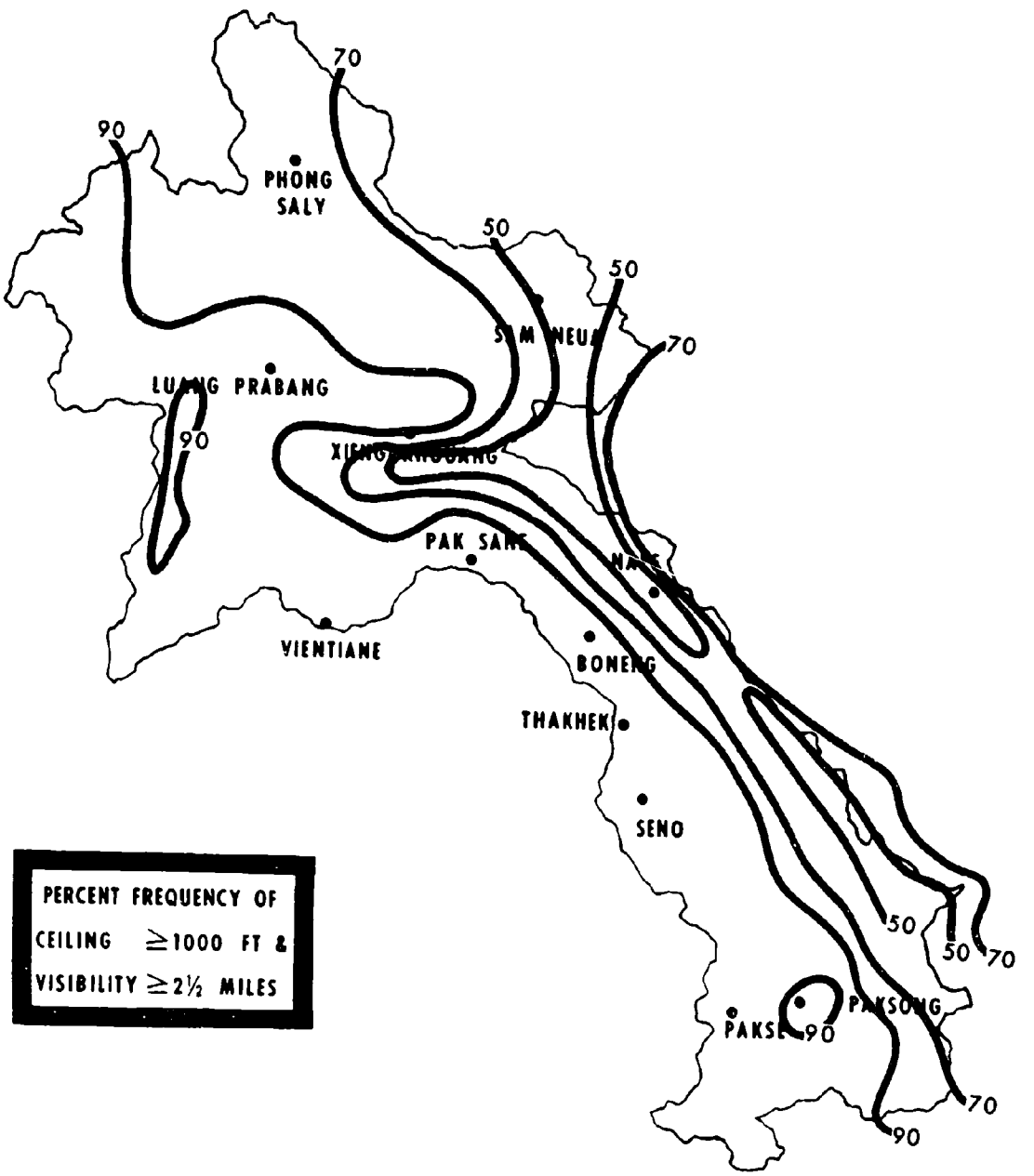


Fig. 17a

JAN

JANUARY SUNRISE, SUNSET AND TWILIGHT FOR VIENTIANE (17°59'N, 102°34'E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0550	0617	0641	1745	1809	1836	1.9	-1.9
2	0551	0618	0641	1746	1810	1837	1.9	-1.9
3	0551	0618	0642	1747	1810	1837	1.9	-1.9
4	0551	0618	0642	1747	1811	1838	1.9	-1.9
5	0552	0619	0642	1748	1811	1838	1.9	-1.9
6	0552	0619	0642	1748	1812	1839	1.9	-1.9
7	0552	0619	0643	1749	1813	1840	1.9	-1.8
8	0553	0619	0643	1750	1813	1840	1.9	-1.8
9	0553	0620	0643	1750	1814	1841	1.9	-1.8
10	0553	0620	0643	1751	1814	1841	1.8	-1.8
11	0553	0620	0644	1752	1815	1842	1.8	-1.8
12	0554	0620	0644	1752	1816	1842	1.8	-1.8
13	0554	0621	0644	1753	1816	1843	1.8	-1.7
14	0554	0621	0644	1753	1817	1844	1.8	-1.7
15	0554	0621	0644	1754	1817	1844	1.8	-1.7
16	0554	0621	0644	1755	1818	1845	1.7	-1.7
17	0554	0621	0644	1755	1819	1845	1.7	-1.7
18	0554	0621	0644	1756	1819	1846	1.7	-1.7
19	0555	0621	0644	1756	1820	1846	1.7	-1.6
20	0555	0621	0644	1757	1820	1847	1.7	-1.6
21	0555	0621	0644	1758	1821	1847	1.7	-1.6
22	0555	0621	0644	1758	1821	1848	1.6	-1.6
23	0555	0621	0644	1759	1822	1848	1.6	-1.6
24	0555	0621	0644	1800	1823	1849	1.6	-1.5
25	0555	0621	0644	1800	1823	1849	1.5	-1.5
26	0555	0621	0644	1801	1824	1850	1.5	-1.5
27	0555	0621	0644	1801	1824	1851	1.5	-1.5
28	0554	0621	0644	1802	1825	1851	1.4	-1.4
29	0554	0621	0643	1802	1825	1851	1.4	-1.4
30	0554	0620	0643	1803	1826	1852	1.4	-1.4
31	0554	0620	0643	1803	1826	1852	1.4	-1.4

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 18a.

B. FEBRUARY

1. Climatic Brief: Although the Siberian High begins a slow retreat northward in February, the flow around it is sufficient to maintain a strong northeast monsoon over Southeast Asia. As the cold dry air from the high pressure area moves southward, it is gradually heated by contact with the warmer China coast and waters of the South China Sea. This polar air merges over the water with warm, moist tropical air from the western Pacific and arrives over Southeast Asia much warmer and more moist than when it left the continent. Compared with the southwest monsoon, the northeast monsoon is relatively cool and dry.

February is one of the least cloudy months of the year over Laos. Precipitation is slight and the entire month's rain for any given location generally falls in one or two isolated showers or thunderstorms. Many regions have a high frequency of early morning fog, but such occurrences are generally much less than that of January and, in general, visibilities are good.

Temperatures begin to increase toward their spring maxima in late February. Although relative humidities throughout Laos are high all year, in the absolute sense, February is a month of decreasing humidity.

2. Temperatures: During February, temperatures are increasing towards a late spring maximum. Temperature data are unavailable for northern Laos; however, available data from neighboring countries indicate that maximum temperatures in that region average 65 to 70F. Mean maximum temperatures in eastern Laos are between 75 and 80F, while those along the Thailand border average between 87 and 89F. The extreme February maximum temperature for Laos is 102F at both Luang Prabang and Seno.

Mean daily minimum temperature range from below 50F along the northern border to 69F at Pakse in the south. The extreme minimum temperature is 39F at Xieng Khouang (elevation 3760ft). (See Fig. 7b)

3. Relative Humidity: Relative humidity is generally high throughout Laos resulting in conditions favorable for mildew, corrosion and decay of susceptible items. The high humidity tends to make high temperatures seem even higher. The highest humidities occur during early morning hours and after rainshowers, while the lowest usually occur during the afternoon. As with temperatures, humidities can vary considerably over short distances. Values used here are based on reporting stations only.

In February, humidities everywhere are decreasing towards the annual minimum which occurs in March. Mean relative humidities range from a high of 71% at Vientiane to a low of 56% at Pakse. The record reported low humidity is 4% at Boneng, 90 mi northwest of Seno. (See Fig. 8b.)

4. Precipitation and Thunderstorms: February is a dry season month throughout Southeast Asia. The Asiatic high pressure cell begins to weaken and the northeast monsoon abates somewhat. This produces less rainfall on exposed eastern coasts and slopes, but allows slight increases of rainfall over other regions.

During February, the majority of precipitation throughout Laos is associated with afternoon convective showers or isolated thunderstorms. Snowfall, although unreported at all observing stations, is possible at higher elevations in northern Laos. However, the colder temperatures usually coincide with dry air, making the probability of snowfall rather small. Hail occurs infrequently over Laos during February.

There is little variability in February rainfall from one year to the next over most of Southeast Asia. Rainless Februarys are common everywhere except along exposed coastal regions. Recorded maximum 24-hr rainfall amounts are relatively high and exceed mean monthly rainfalls everywhere.

There is a slight increase in February precipitation over that of December and January. Generally, local rainfalls come from 1 or 2 isolated thunderstorms, and the remainder of the month is rainless. Rainfall is generally light and daily amounts in excess of 1 in. are rare. Precipitation can be expected on only one to three days, except at several locations in the Annam Range, where passes allow exposure to strong surges of the northeast monsoon and precipitation occurs on 4 days.

Recorded mean monthly precipitation amounts are less than 1 in. over most of the country. Stations in the extreme north and in the Annam Range exposed to the northeast monsoon receive amounts between 1 and 2 in.

Maximum recorded monthly precipitation values range from 1 to 5 in. over the majority of Laos, and exceed 5 in. only over the relatively narrow, northern part of the panhandle. The maximum reported February rainfall for the country is 8.6 in. at Nape.

Completely dry Februarys (minimum monthly precipitation amounts of zero) are frequent throughout the country, except over the Annam Range, where rainfall is likely each year over those portions close to the Gulf of Tonkin.

Maximum 24-hr precipitation values vary from less than 1 in. over a region west of Vientiane to more than 3 in. over small regions near Luang Prabang and Seno. The highest February 24-hr rainfall on record is 3.5 in. at Boneng.

Thunderstorm activity increases slightly over Laos during February but still remains on the order of one day per month. Primarily they occur during the afternoon, occasionally extending into the night along the Mekong Valley. The incidence of thunderstorm activity may be greater along the higher mountain ridges, but observational data from such regions are lacking. (See Fig 9b, 10b and 11b)

5. Cloudiness: Cloudiness increases slightly over most of the panhandle during February, while over the northern half of the country it is decreasing toward a March minimum. Cloudless skies exist over most regions 60 to 70% of the time prior to 1100 LST.

River fogs in northern valleys rise to become stratus ceilings below 1,000 ft before burning off by midmorning. Convective clouds, with bases 2,000 to 4,000 ft form, over most areas during late morning hours, but few afternoons have broken clouds.

Mean cloudiness varies from less than 30% over Thailand border regions west of Luang Prabang to about 50% along much of the North Vietnam border region.

Widely scattered clouds (3/10 or less sky cover) are observed on 15 to 20 days over most of the country; however, they can be expected on only 5 to 10 days in the extreme north and on about 12 days over the Annam Range along the Vietnam border.

6. Visibility and Obstructions to Vision: February is a month of contrasting visibilities. Some of the best afternoon visibilities of the year occur over mountainous regions, while some of the worst visibilities occur in haze and smoke over central Laos. Areas where valley fog and river stratus are prevalent experience some of the year's poorest morning visibilities.

In general, surface visibilities are best during the afternoon and slant range visibilities are best between 0800 and 1100 LST. Fresh surges of the northeast monsoon improve visibilities everywhere, however, visibilities of greater than 12 mi are not common anywhere over the country.

February is still one of the foggiest months of the year over Laos. Visibilities of less than 3 mi can be expected with early morning fog in river valleys of the northern half of the country. Radiation fogs are most likely over river valleys, and most prevalent and persistent in deep, steep sided valleys. Fogs generally form around 0400 LST and dissipate by 0900 LST, but in deeper valleys, they may form earlier and persist throughout the morning. Fog is observed on as many as half the days of the month at 0700 LST in northern Laos at major observing sites and may occur more frequently at other locations but goes unrecorded. Haze and smoke restrict daytime visibilities along the Mekong River but visibilities of less than 3 mi are infrequent. (See Fig 12b and 13b.)

7. Wind and Temperatures Aloft: There is little change in wind speeds and direction from January to February over Laos.

The prevailing 2,000 ft flow over most of Laos varies from easterly to southeasterly during February. Local surface winds, both speeds and direction, are influenced by local topography and can deviate considerably from the mean flow. Winds with easterly components extend aloft to about 3,000 ft over northern Laos, and about 5,000 ft over the southern part of

the country increase in strength, while over the south they become light and variable. At 30,000 ft and above, winds are southwesterly to westerly and increase in strength over all of Laos.

In the vertical, temperature decreases approximately 3.3F for every 1,000 ft in the lower atmosphere. The mean height of the freezing level varies from 12,000 ft in the north to near 15,000 ft in southern Laos, but the actual height may be found to vary as much as 3,000 ft from the mean levels. At 25,000 ft the air temperature is close to -18C.

8. Combined Ceiling and Visibility: Ceilings and visibilities are poorest during the early morning hours near sunrise with visibilities being the major restrictant. Ceilings of 5,000 ft or more accompanied by visibilities of at least 5 mi ($\geq$5,000/5) occurs less than 10% of the time along the crests of the Chaine Annamatique and over the Plaine des Jarres, and more than 70% over the Mekong River Basin in the panhandle. There is no essential change in this pattern from early morning to mid-afternoon, however, there is a noticeable improvement in conditions over the mountains where the frequency of $\geq$5,000/5 increases to at least 30% by mid-afternoon. Elsewhere there is only slight improvement in $\geq$ 5,000/5, primarily due to an increase in afternoon cloudiness below 5,000 ft offsetting any improvement in visibility.

The frequency of $\geq$ 1,000/2½ is also at a minimum during the early morning hours and is as low as 30% along the crest of the Chaine Annamatique improving to near 90% along the Mekong River. By mid-afternoon, considerable improvement normally takes place, particularly over the northern half of the country. Only over the Plaine des Jarres region in the vicinity of Sam Neua is the frequency lower than 50%. Elsewhere frequencies exceed 90%. (See Fig. 14b, 15b, 16b and 17b)

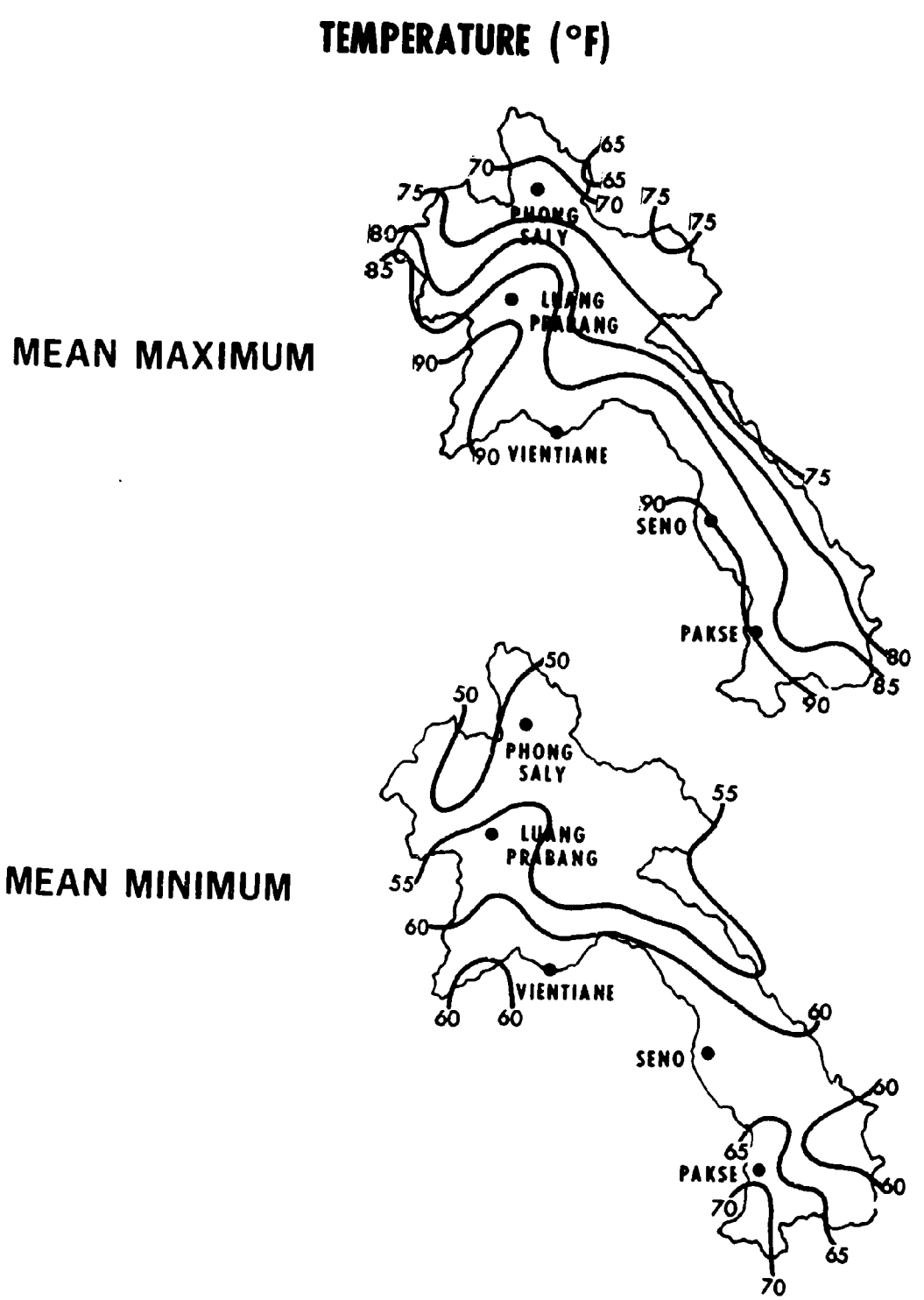

TEMPERATURE (°F)
MEAN MAXIMUM
65
70
65
75
70
75
175
PHONG SALY
180
85
LUANG PRABANG
190
190 VIENTIANE
75
190
SENO
PAKSE
80
85
90
MEAN MINIMUM
50
50
PHONG SALY
55
LUANG PRABANG
55
60
VIENTIANE
60
60
60
SENO
60
65
PAKSE
60
70
65
70
FEB

Fig. 7b.

MEAN RELATIVE HUMIDITY (%)

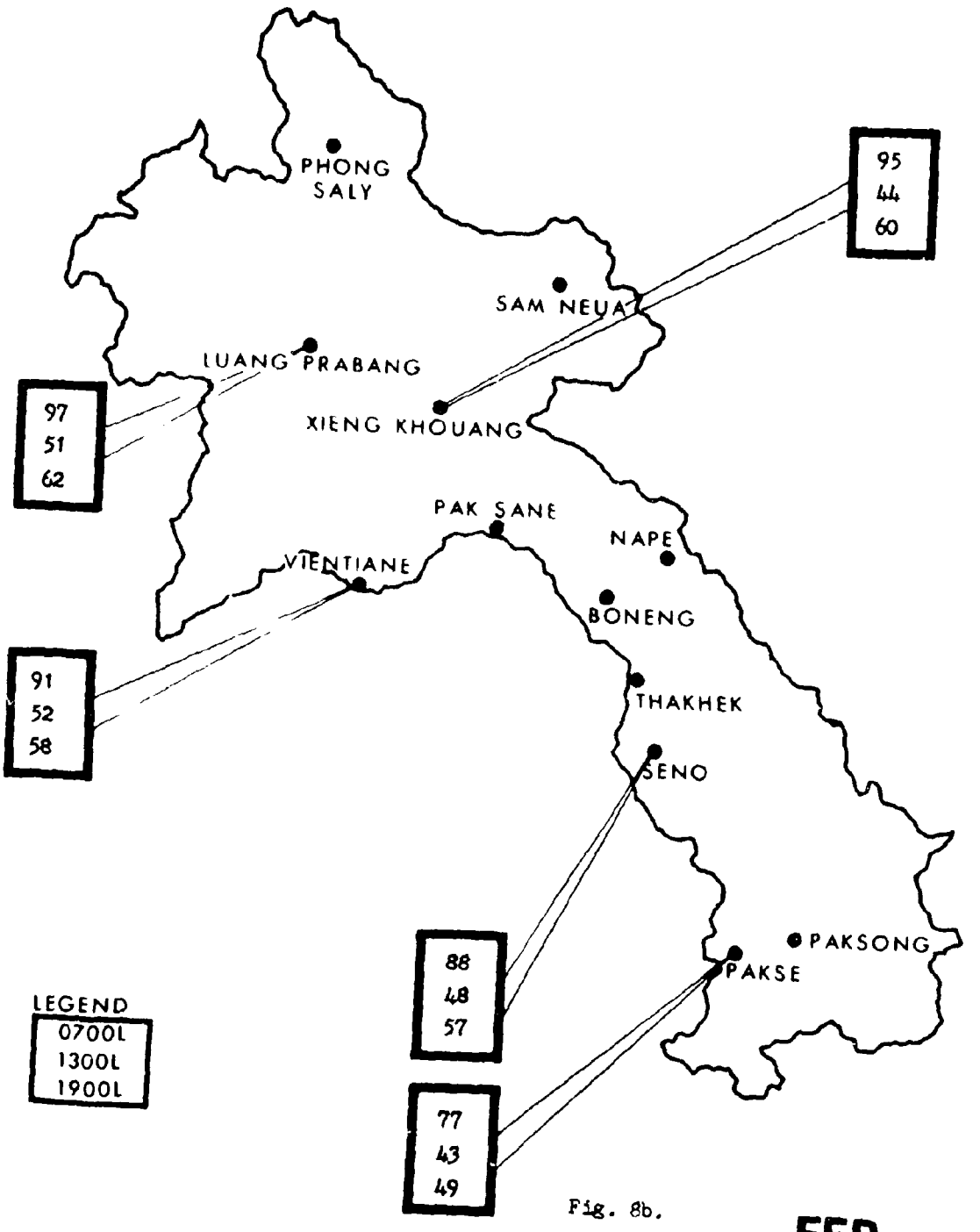


Fig. 8b.

FEB

MEAN NUMBER OF DAYS WITH PRECIPITATION

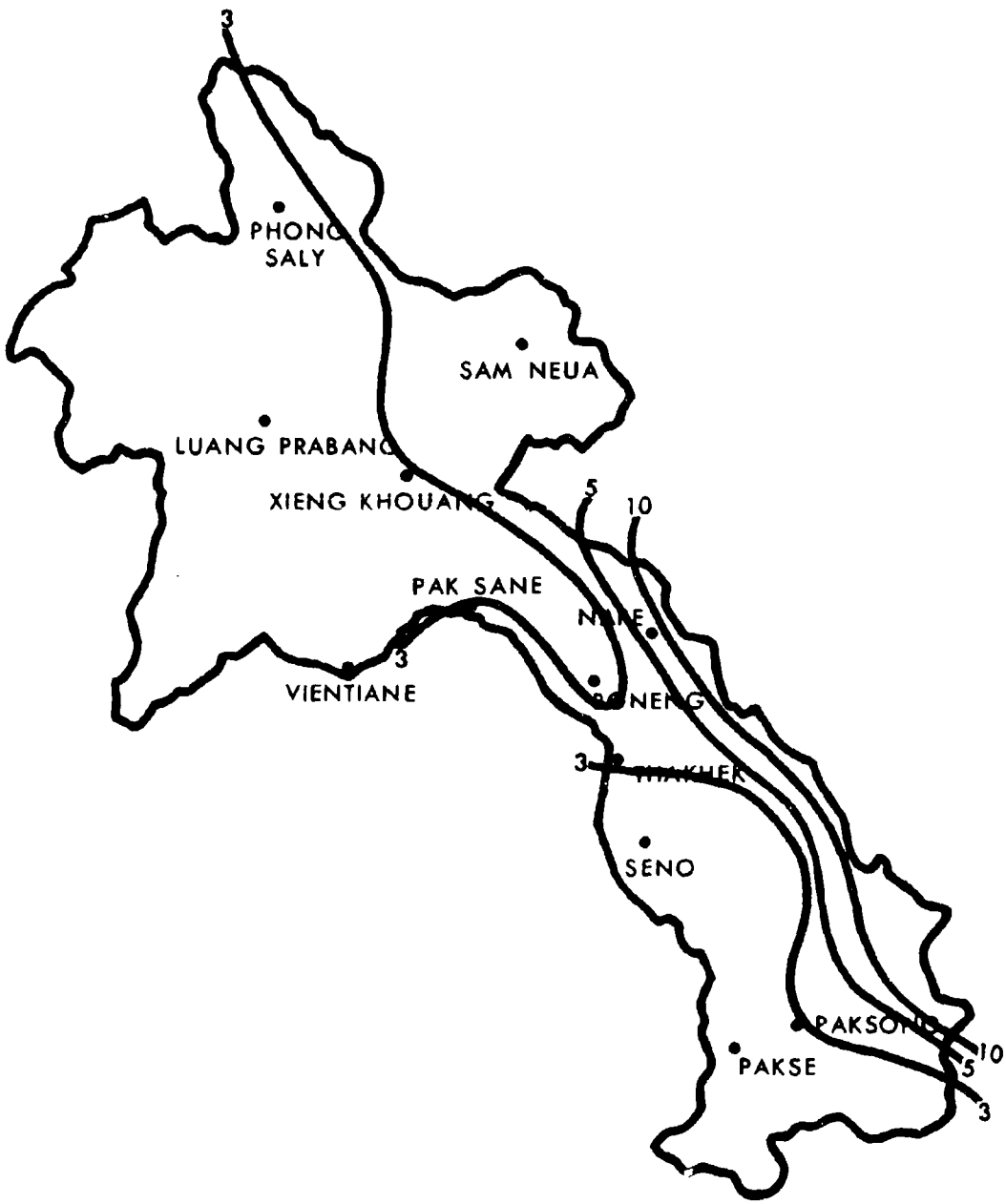


Fig. 9b.

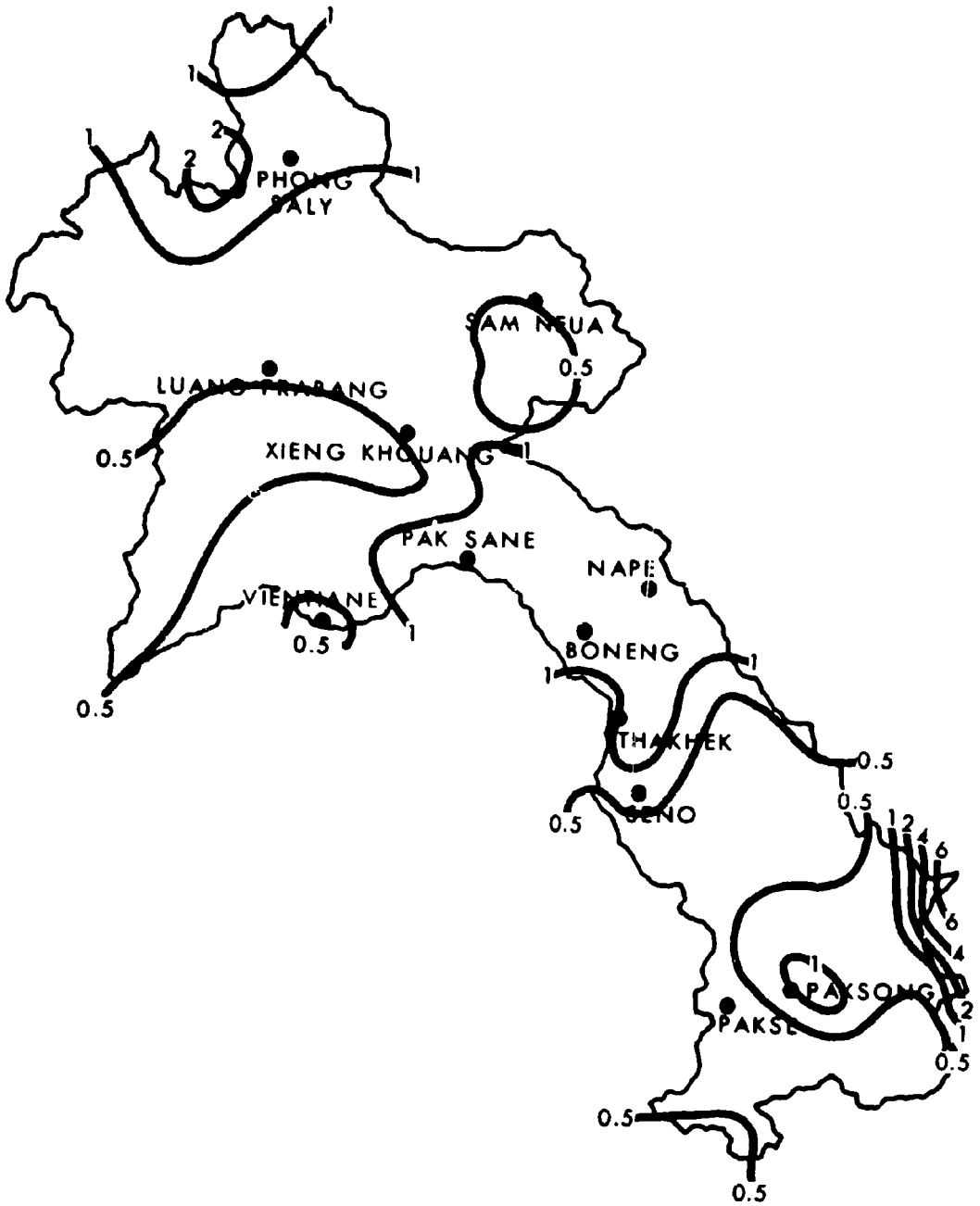

MEAN PRECIPITATION (in)
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
PAKSE
FEB

Fig. 10b

PRECIPITATION and THUNDERSTORMS

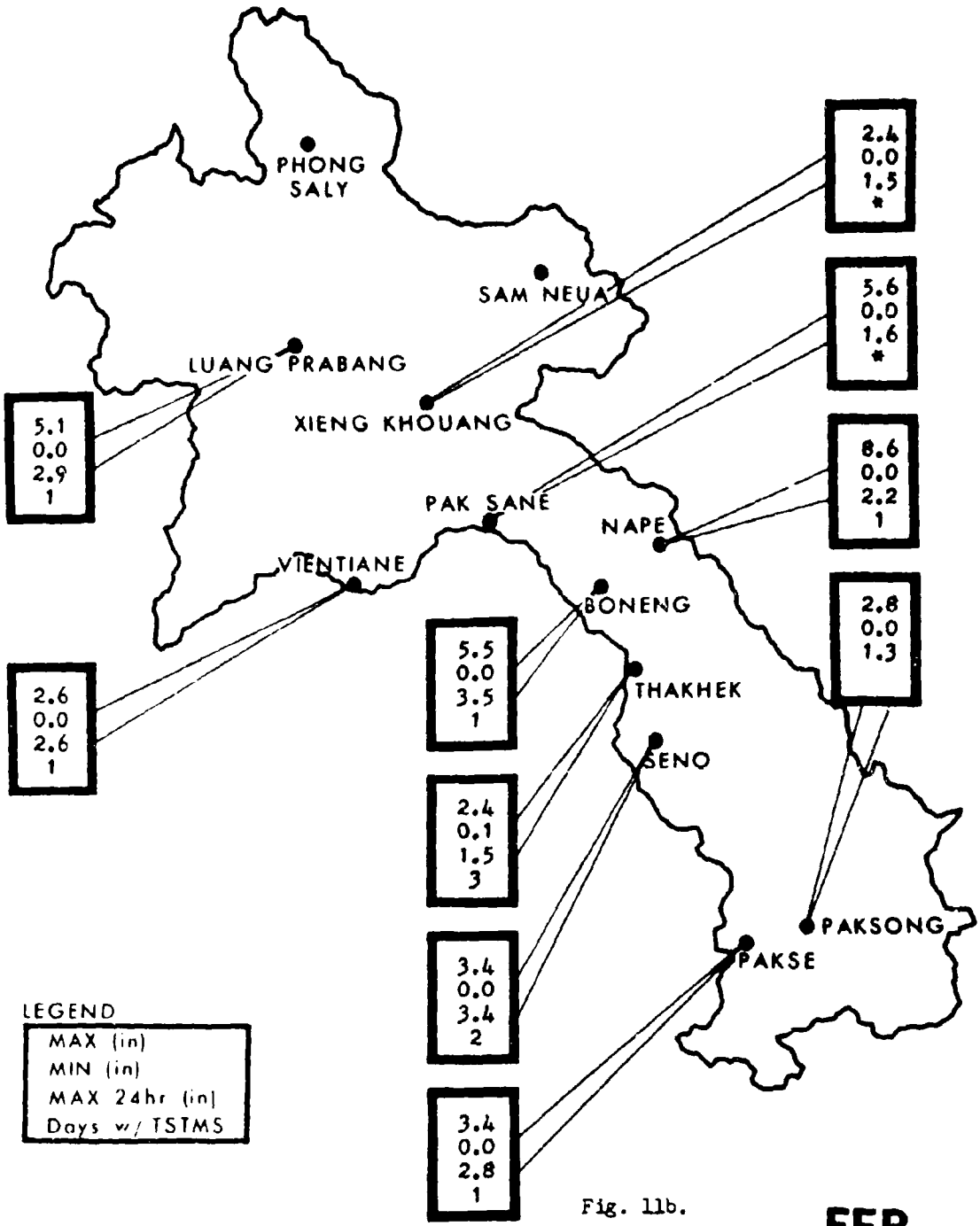


Fig. 11b.

FEB

VISIBILITY

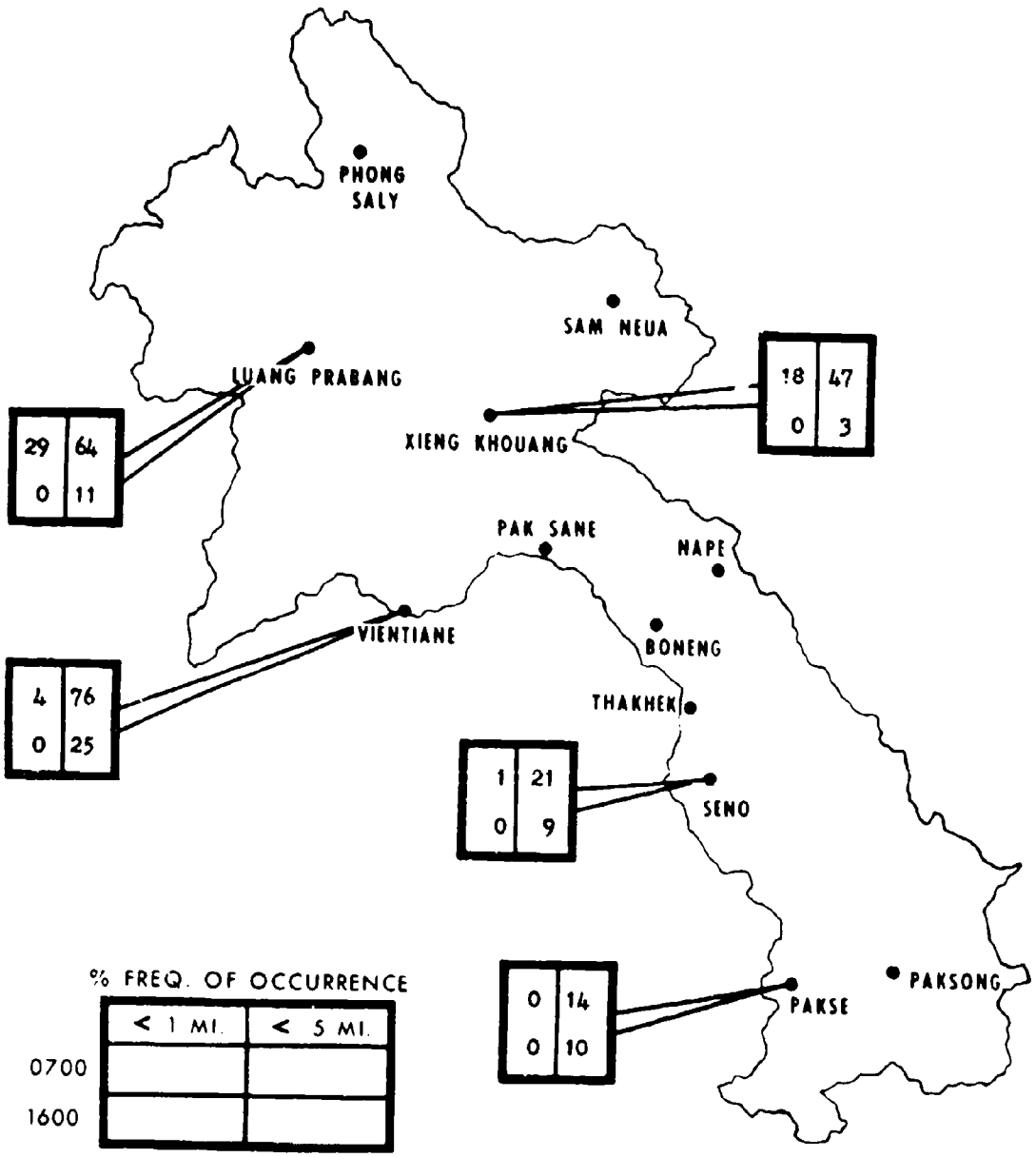


Fig. 12b.

FEB

FOG-SMOKE/HAZE

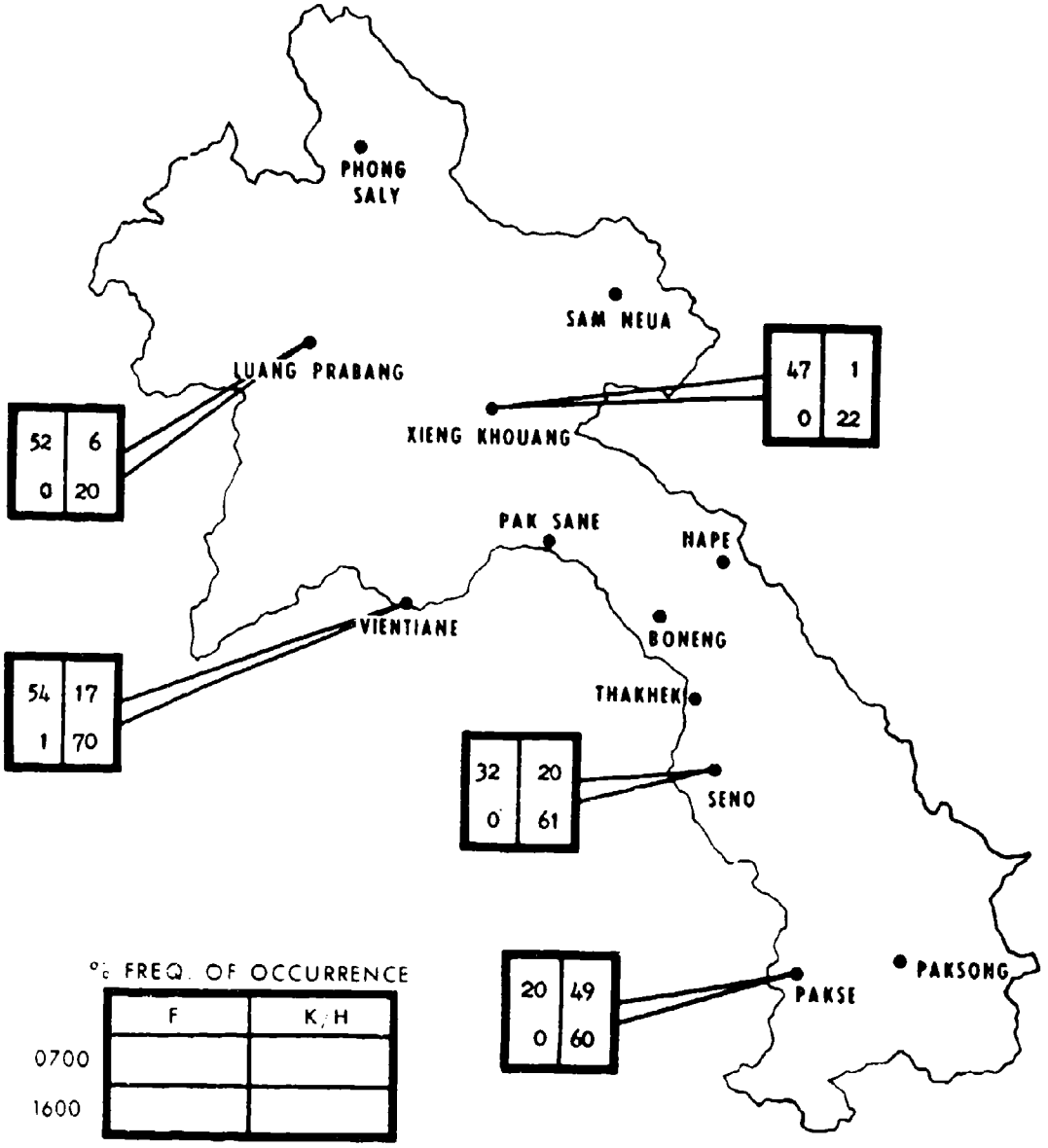


Fig. 13b.

CEILING/VISIBILITY

(0700 LST)

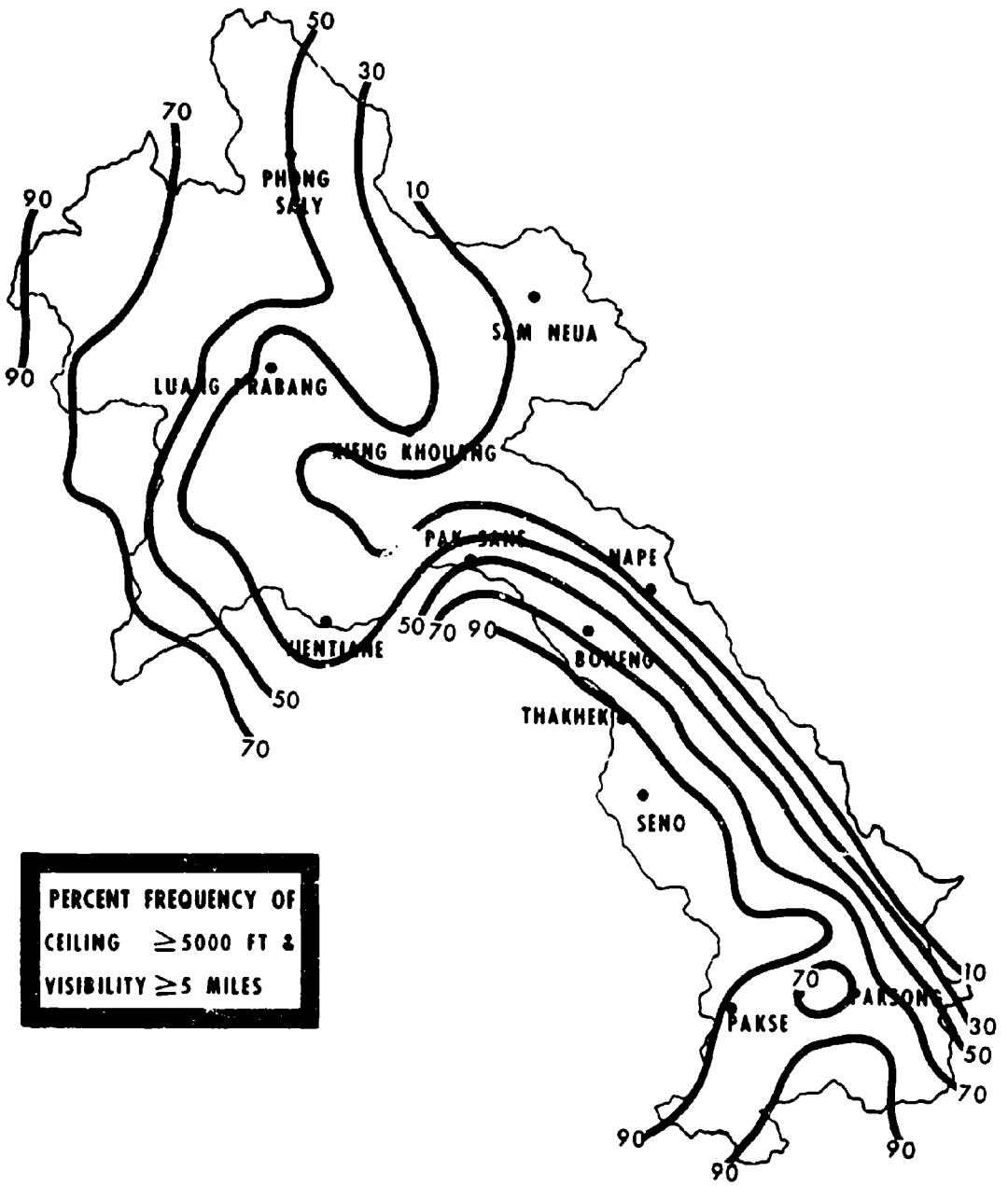


Fig. 14b

FEB

CEILING/VISIBILITY

(1600 LST)

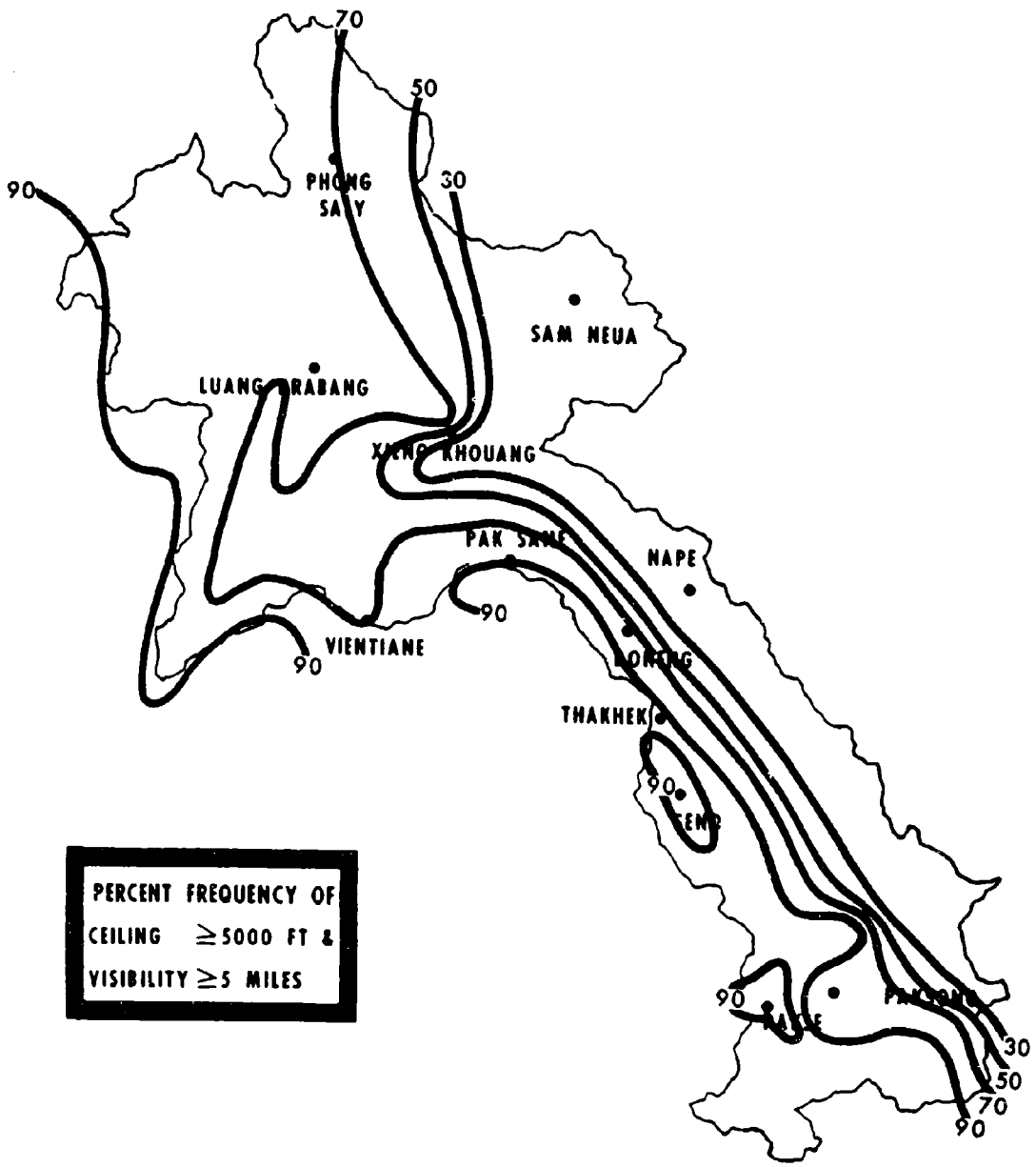


Fig. 15b

FEB

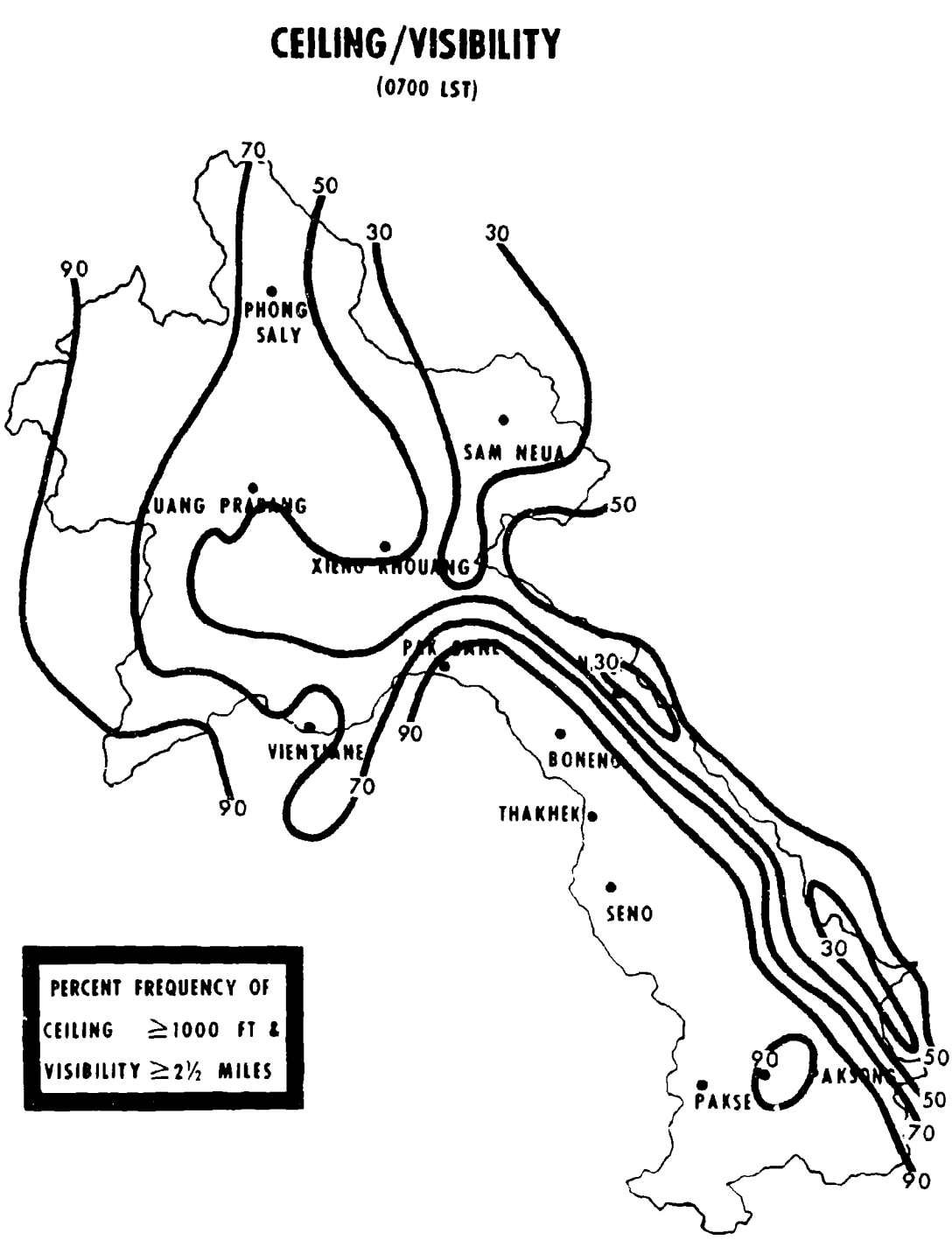

CEILING/VISIBILITY
(0700 LST)
70
50
30
30
90
PHONG SALY
SAM NEUA
50
90
VIENTIANE
BONENG
70
90
THAKHEK
SENO
30
90
50
50
70
90
PERCENT FREQUENCY OF
CEILING ≥1000 FT &
VISIBILITY ≥2½ MILES
FEB

Fig. 16b

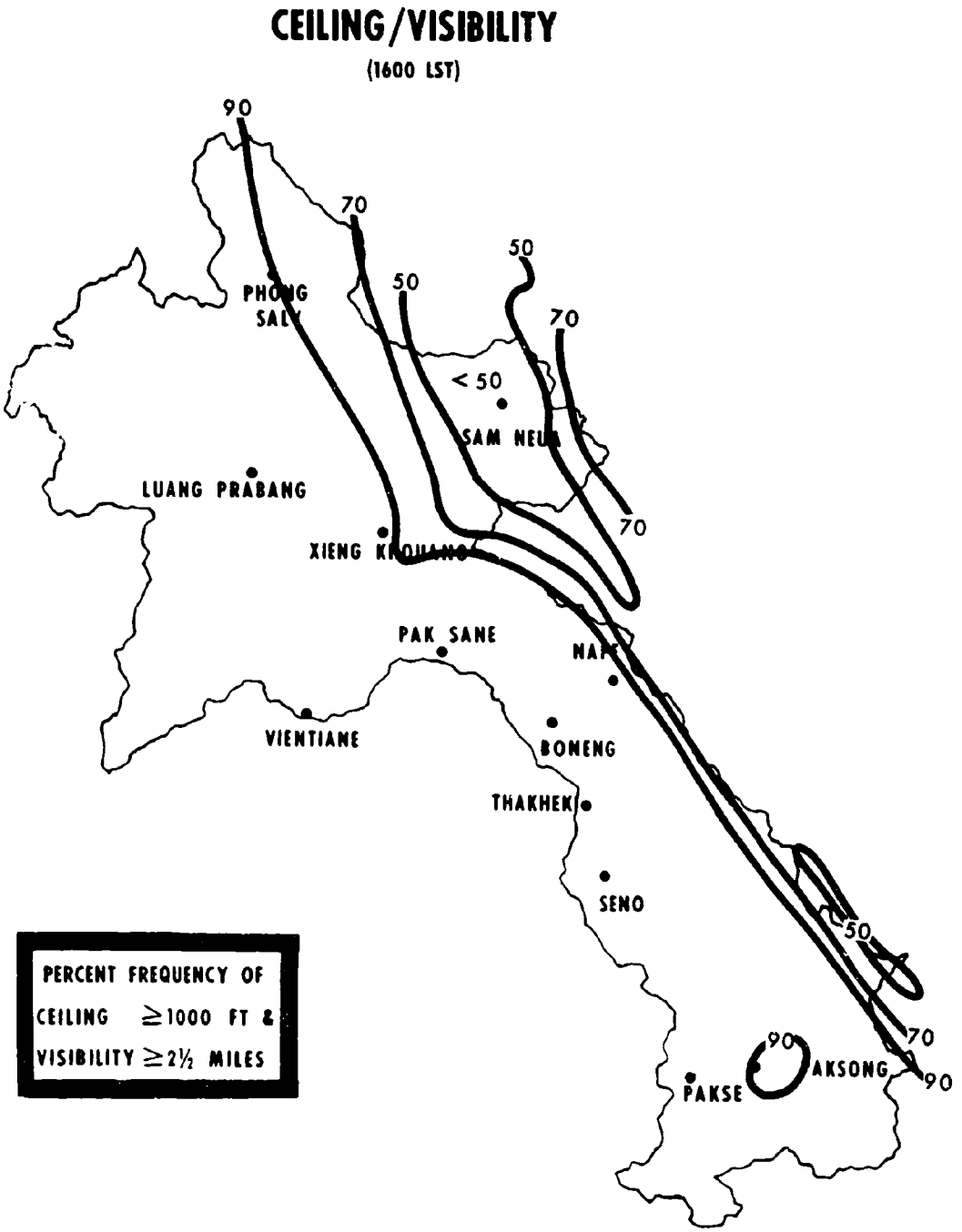

CEILING/VISIBILITY
(1600 LST)
90
70
50
50
70
< 50
70
50
90
70
90
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSE
AKSONG
PERCENT FREQUENCY OF
CEILING ≥1000 FT &
VISIBILITY ≥2½ MILES

Fig. 17b

FEB

FEBRUARY SUNRISE, SUNSET AND TWILIGHT FOR VIENTIANE (17°59'N, 102°34'E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0554	0620	0643	1804	1827	1853	1.4	-1.4
2	0554	0620	0643	1805	1827	1853	1.4	-1.4
3	0553	0620	0642	1805	1828	1854	1.3	-1.3
4	0553	0619	0642	1806	1828	1854	1.3	-1.3
5	0553	0619	0642	1806	1829	1855	1.3	-1.3
6	0553	0619	0641	1807	1829	1855	1.2	-1.2
7	0552	0618	0641	1807	1830	1856	1.2	-1.2
8	0552	0618	0641	1808	1830	1856	1.2	-1.2
9	0552	0618	0640	1808	1830	1856	1.2	-1.1
10	0551	0617	0640	1809	1831	1857	1.1	-1.1
11	0551	0617	0639	1809	1831	1857	1.1	-1.1
12	0551	0617	0639	1809	1832	1858	1.1	-1.0
13	0550	0616	0638	1810	1832	1858	1.1	-1.0
14	0550	0616	0638	1810	1833	1858	1.0	-1.0
15	0550	0615	0637	1811	1833	1859	1.0	-0.9
16	0549	0615	0637	1811	1833	1859	1.0	-0.9
17	0549	0614	0636	1812	1834	1859	1.0	-0.9
18	0548	0614	0636	1812	1834	1900	0.9	-0.9
19	0548	0613	0635	1812	1834	1900	0.9	-0.8
20	0547	0613	0635	1813	1835	1900	0.9	-0.8
21	0547	0612	0634	1813	1835	1901	0.8	-0.8
22	0546	0612	0634	1813	1835	1901	0.8	-0.8
23	0545	0611	0633	1814	1836	1901	0.8	-0.7
24	0545	0610	0632	1814	1836	1902	0.7	-0.7
25	0544	0610	0632	1814	1836	1902	0.7	-0.7
26	0544	0609	0631	1815	1837	1902	0.7	-0.7
27	0543	0609	0630	1815	1837	1902	0.6	-0.6
28	0542	0608	0630	1815	1837	1903	0.6	-0.6
29	0542	0608	0630	1816	1838	1903	0.6	-0.6

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 18b.

C. MARCH

1. Climatic Brief: Laos remains under the influence of the northeast monsoon during the first half of March. The air is relatively cool and dry since it originates over continental Asia. However, it does pick up considerable moisture during its trajectory over the waters of the South China Sea and causes extensive cloudiness along the east coasts of North and South Vietnam. By the time the northeast flow crosses the Annam Range and enters Laos, most of the cloud producing moisture and has been removed.

The panhandle shows a gradual increase in cloudiness from a January - February minimum. Most of the increase is due to convective type activity and follows the normal cycle of a daytime maximum and nighttime minimum. Elsewhere there is little change. The whole area is prone to brush and forest fires as a result of the long dry season, and the smoke plus dust contributes to low visibilities. Thunderstorms and rain showers tend to alleviate this situation in some areas toward the end of the month. The country remains relatively dry but experiences a slight increase in precipitation during the latter part of the month. Most of the country shows a considerable increase in thunderstorm activity. Temperatures continue to rise throughout March with the highest temperature of the year occurring in late March and April. Relative humidity reaches an annual minimum.

2. Temperatures: During March temperatures are still increasing slightly towards their annual maximum in April. No temperature data are available for northern Laos, but available data from neighboring countries indicate that daily maximum temperatures in that region are 70 to 80F. Maximum temperatures over the remainder of Laos are between 80 and 95F. The highest reported mean maximum is 94F at Pakse and the lowest mean maximum is 80F at Pak Song (elevation 3937 ft). The extreme high temperature on record is 108F at Seno.

Mean daily minimum temperatures range from about 55F in the northern mountains to about 70F in the extreme southern end of the country. The lowest reported mean minimum is 55F at Xieng Khouang and the highest is 73F at Pakse. The extreme low temperature on record is 44F at Pak Song. (See Fig. 7c.)

3. Relative Humidity: Relative humidity is high throughout the country and results in conditions favorable for mildew, corrosion, and decay of susceptible items. The high humidity tends to make the high temperature seem even higher. The highest daily humidities occur during early morning hours and after rainshowers, while the lowest values usually occur during the afternoon. As with temperature, humidity can vary considerably over short distances. Values discussed here are based on reporting stations only.

Relative humidity is at its annual minimum throughout Laos. Mean March relative humidities range from 70% at Vientaine to 56% at Pakse. The record low humidity is 10% at Luang Prabang. (See Fig. 8c.)

4. Precipitation and Thunderstorms: Although March is a dry season month over Southeast Asia, rainfall increases almost everywhere. As the northeast monsoon weakens and its winds become lighter and more variable the frequency of convective showers increases. In general, rainfall amounts are three to four times those received in February. Throughout the country the majority of precipitation is associated with afternoon and evening showers. There is considerable variation in March rainfalls from one year to the next and rainless, or near rainless Marches have occurred throughout the country. Although March is considered a dry season month in Laos, rainfall amounts are on the increase as convective cloudiness becomes more frequent. Precipitation is generally light and a daily rainfall in excess of 0.5 in. at any given location is rare.

The mean number of days with measurable precipitation range from 2 days over western mountains to 8 days over windward slopes of the Annam Range. Mean monthly amounts over much of the country average between 1 and 2 in. except on the western slopes of the Annam Range, northeast of Vientaine and on the Plateau des Bolovens. In these two regions the average is 4 to 5 in.

Maximum monthly precipitation ranges from 3 to 4 in. over most of the country but have been recorded as high as 8 in. at some isolated exposed mountain stations. Minimum monthly precipitation is zero or near zero throughout the country. The maximum 24-hr amounts on record vary between 2 and 4 in.

March brings a rapid and significant increase in thunderstorm activity over almost all of Laos save the northernmost regions. As the northeast monsoon wanes, low-level winds become more southerly over the southern portions of the country. These southerly winds carry warm moist air far inland where it is further heated by the sun. When the cool, dry, northerly air overrides this warm low-level air, extreme instability occurs, causing violent afternoon and evening thunderstorms. Northern Laos observes zero to 2 thunderstorms days in March while stations along the Thailand border and the panhandle report from 5 to 9 days. (See Figs. 9c, 10c and 11c.)

5. Cloudiness: Over northern Laos there is very little change in conditions from those experienced in February and cloudiness is at its annual minimum. While cloudiness remains at a minimum over the northern mountains, it gradually increases over the panhandle region of Laos. River fog in northern valleys rises to become stratus, with ceilings generally below 1,000 ft, before burning off by midmorning. Convective clouds, with bases 2,000 to 4,000 ft, form over most regions during late morning hours, but afternoon ceilings are infrequent. There is an increase in thunderstorm clouds everywhere, with the most notable being along the western slopes of the Annam Range.

Mean cloudiness is greatest around Pak Song where the mean cloudiness is 53% and is least near Luang Prabang where the average is as low as 30%. The mean number of days with total cloud cover equal to or less than 3/10 ranges from 10 days at stations along the Vietnam borders to near 20 days at those along the Thailand border.

6. Visibility and Obstructions to Vision: As during other northeast monsoon months, March is a month of visibility extremes. The worst morning visibility usually occurs in valley fog, particularly in the northern mountains, and the poorest afternoon visibility generally occurs in haze and smoke over the panhandle and Mekong Valley regions. In general, surface visibility is best during the afternoon and slant range visibility best between 0800 and 1100 LST. Subsiding air above relatively cool northeast monsoonal air tends to produce a temperature inversion near 10,000 ft, the average top of the monsoonal flow. Smoke and haze from grass, brush and forest fires, as well as from slash-and-burn farming techniques, is trapped below this inversion, producing visibilities of 1 to 3 mi. Afternoon shower activity helps to improve visibility temporarily while fresh surges of the northeast monsoon improve the visibility everywhere. Visibilities greater than 12 miles are not common anywhere over Laos.

March is one of the foggiest months of the year over Laos. There is a slight decrease from February in the incidence of fog recorded at observing stations and this results in a slight improvement in the frequency of low visibilities. This is offset however, by a slight increase in the frequency of haze and smoke and corresponding increase in the frequency of visibilities less than 5 mi. Daytime visibilities of less than 5 mi occur as much as 50% of the time even in mid-afternoon at some locations.

Visibilities of less than 3 mi can be expected with early morning fog or stratus in river valleys of the northern half of the country. Radiation fog is most likely over river valleys and most prevalent and persistent in deep, steep-walled valleys. Fog generally forms during pre-dawn hours and dissipates by 0900 LST. In deeper valleys, fog may form earlier and persist longer and it is likely that fog forms more frequently than indicated by observed figures in the mountain river valleys of northern Laos.

The western portion of Laos is the foggiest. In this region fog is observed 35 to 55% of the time in the early morning. Over the panhandle this figure is 25% or less. Smoke and haze is observed everywhere from 40 to 70% of the time in mid-afternoon. (See Figs. 12c and 13c.)

7. Wind and Temperatures Aloft: There is relatively little change in wind flow over Laos between February and March.

Over most of Laos traces of the southwest monsoon begin to appear at low levels, producing prevailing winds with a southerly component. Local surface winds, direction and speed, are influenced by local topography and can deviate significantly from mean levels.

Over the northern portions of the area the upper-level westerly winds of the northeast monsoon are merging with low-level southerly flow. Northeast monsoonal flow extends aloft to a little over 10,000 ft over most of the country. Above 25,000 ft the prevailing winds are southerly to southwesterly over all the country. In the vertical, temperatures decrease approximately 3.3F for every 1,000 ft in the lower atmosphere. The mean height of the freezing level varies from 13,000 ft in the north to 15,000 ft in the south, but the actual height may be found to vary as much as 3,000 ft from the mean levels. At 25,000 ft the air temperature is close to -18C.

8. Combined Ceiling and Visibility: Ceiling and visibilities are poorest during the early morning hours near sunrise with visibilities being the major restrictant. Ceilings of 5,000 ft or more accompanied by visibilities of at least 5 miles ($\geq$5000/5) occurs less than 10% of the time along the eastern border region of the crest of the Chaine Annamatique and does not exceed 30% in much of the region between Vientiane and Luang Prabang. Only along the Mekong River in the panhandle does the frequency of $\geq$5000/5 reach as high as 90%. Between early morning and mid-afternoon there is considerable improvement in conditions, with $\geq$5000/5 occurring at least 30% of the time over the Chaine Annamatique, the worst region, and as often as 90% of the time over the Mekong Valley in the panhandle.

The frequency of $\geq$1000/2 1/2 is also at a minimum during the early morning hours, and is somewhat less than 50% along most of the eastern border region and that region just north of Vientiane extending to Luang Prabang. Over most of the Mekong River basin the frequency of $\geq$1000/2 1/2 is 90% or more. Considerable improvement in the areas of low frequency generally takes place by mid-afternoon. Frequencies as low as 50% are confined primarily to a narrow band along the eastern border on the crest of the Chaine Annamatique. More than half the country has a frequency higher than 90%. (See Figs. 14c, 15c, 16c and 17c.)

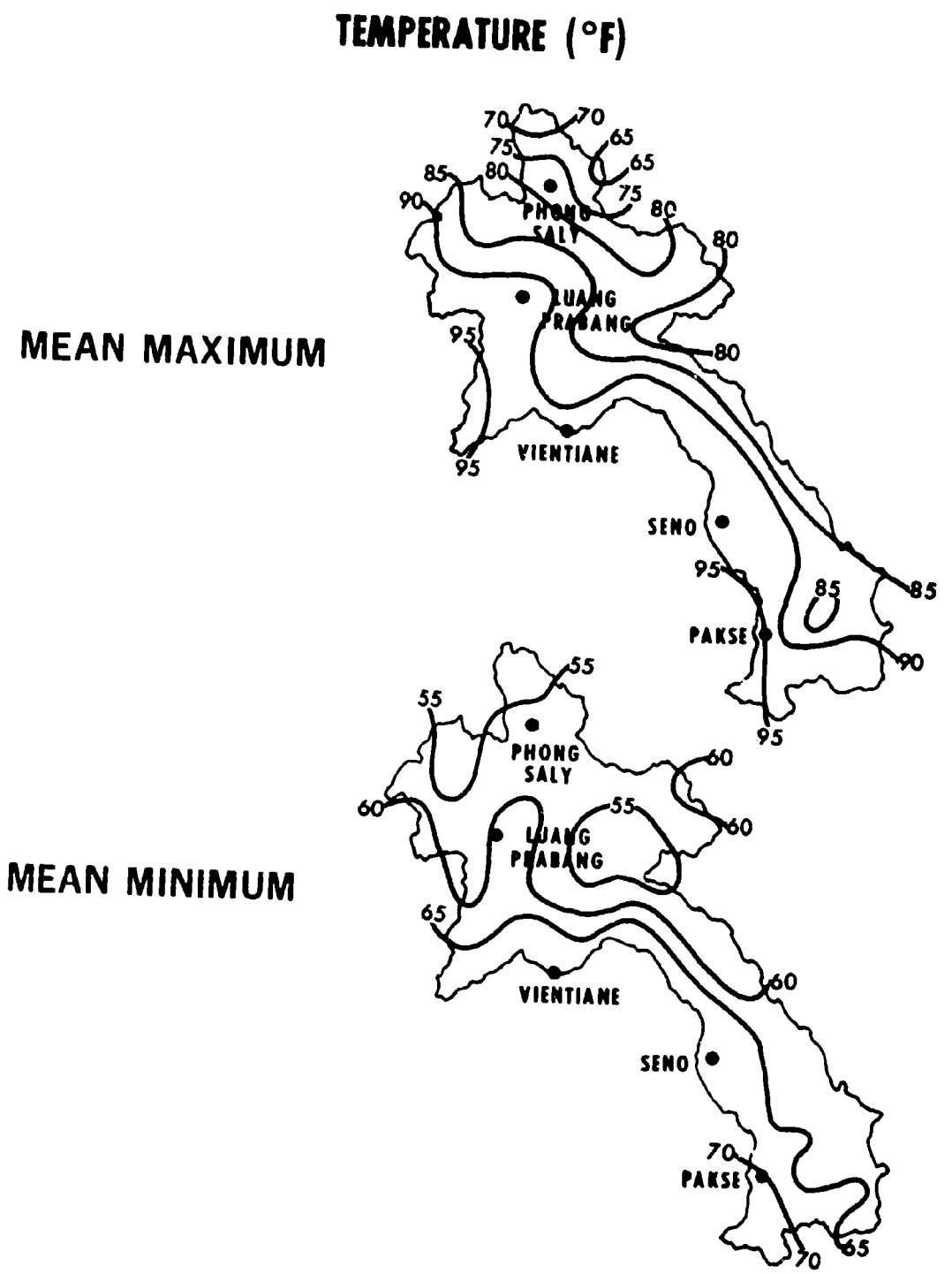

TEMPERATURE (°F)
MEAN MAXIMUM
MEAN MINIMUM
70
70
65
75
65
85
80
75
90
80
PHONG SALY
80
LUANG PRABANG
95
80
VIENTIANE
95
SENO
95
85
85
PAKSE
90
55
55
95
PHONG SALY
60
60
55
60
LUANG PRABANG
65
60
VIENTIANE
SENO
70
PAKSE
70
65

Fig. 7c.

MAR

MEAN RELATIVE HUMIDITY (%)

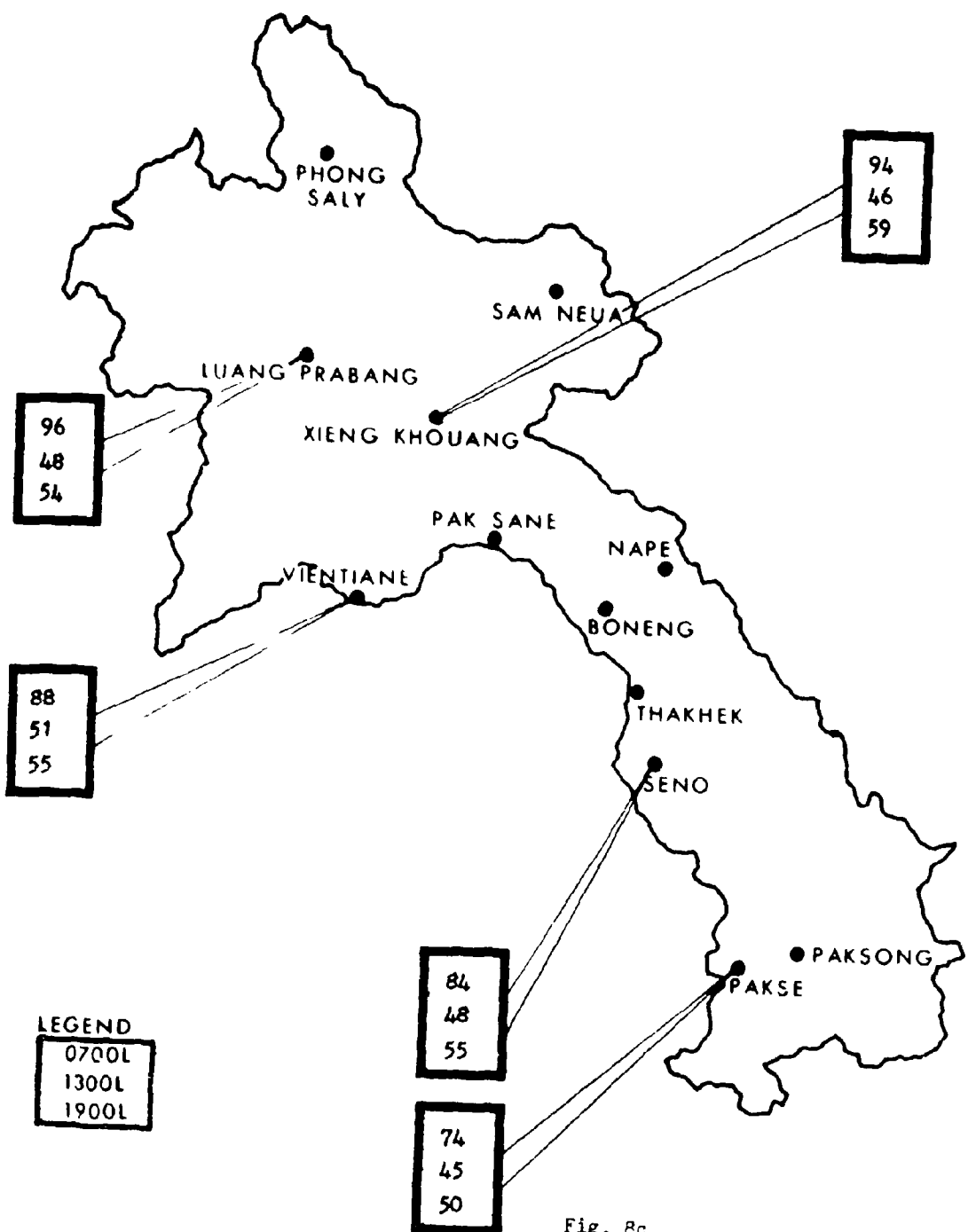


Fig. 8c.

MAR

MEAN NUMBER OF DAYS WITH PRECIPITATION

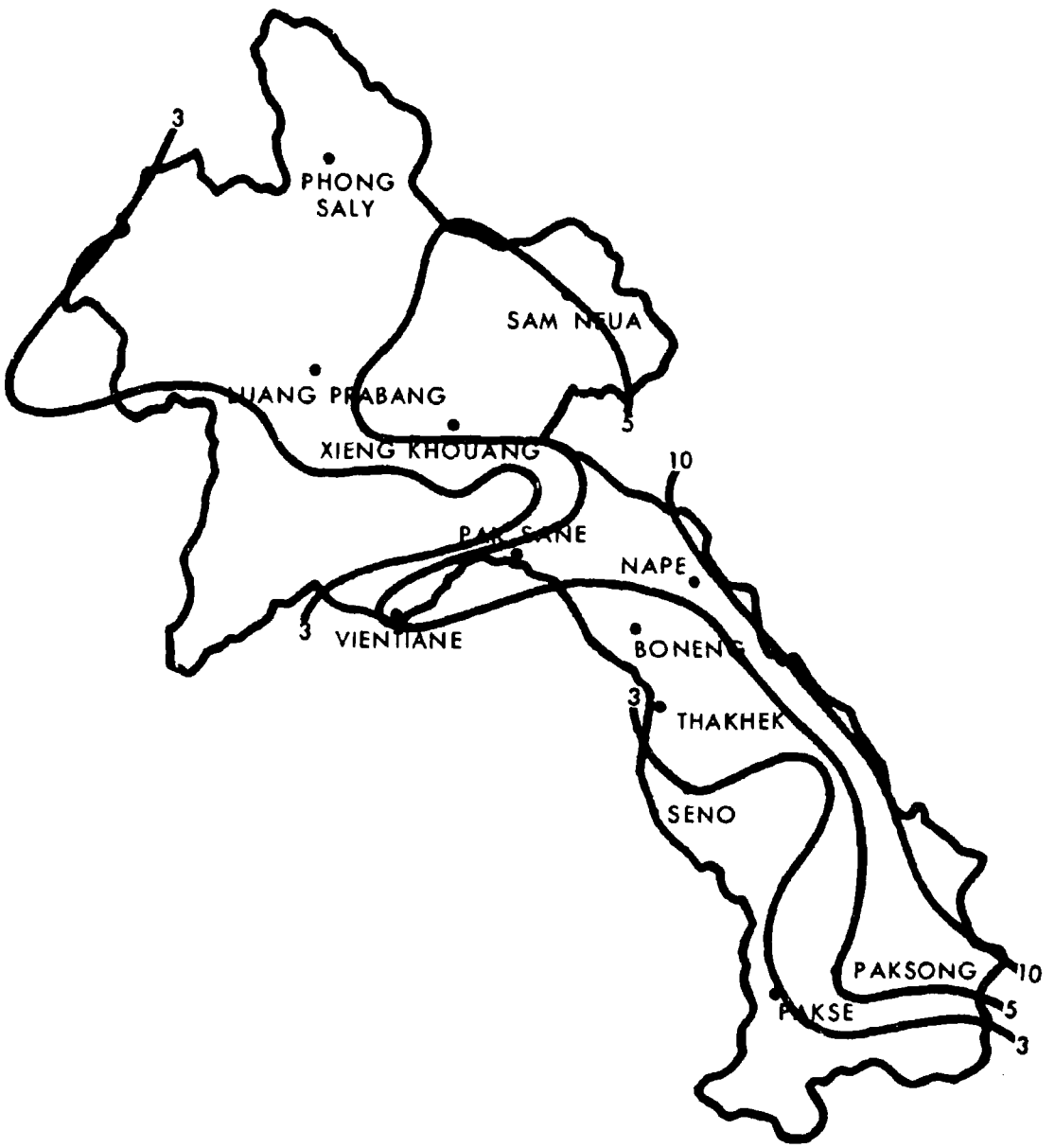


Fig. 9c.

MAR

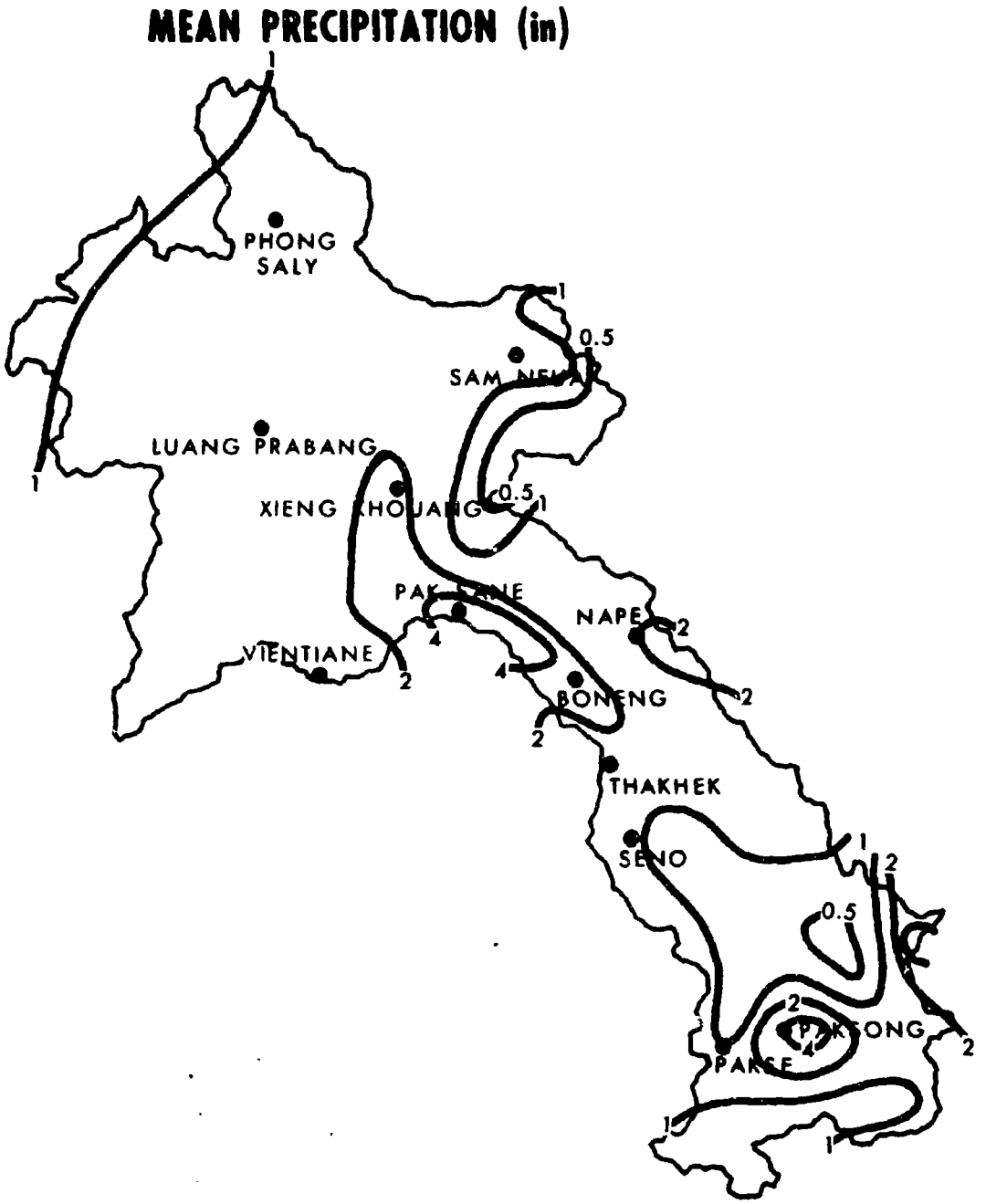

MEAN PRECIPITATION (in)
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAKSANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
PAKSE
MAR

Fig. 10c

PRECIPITATION and THUNDERSTORMS

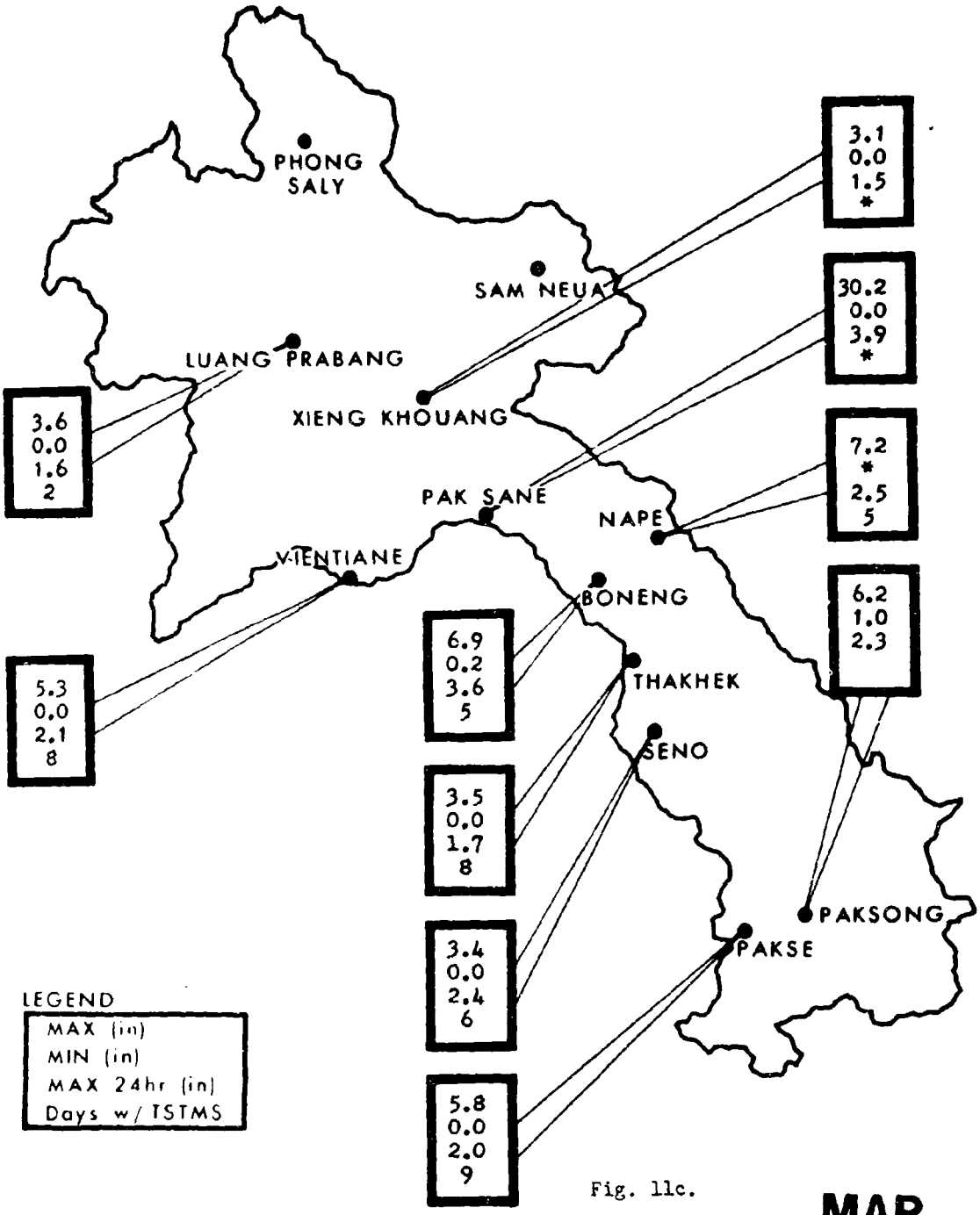
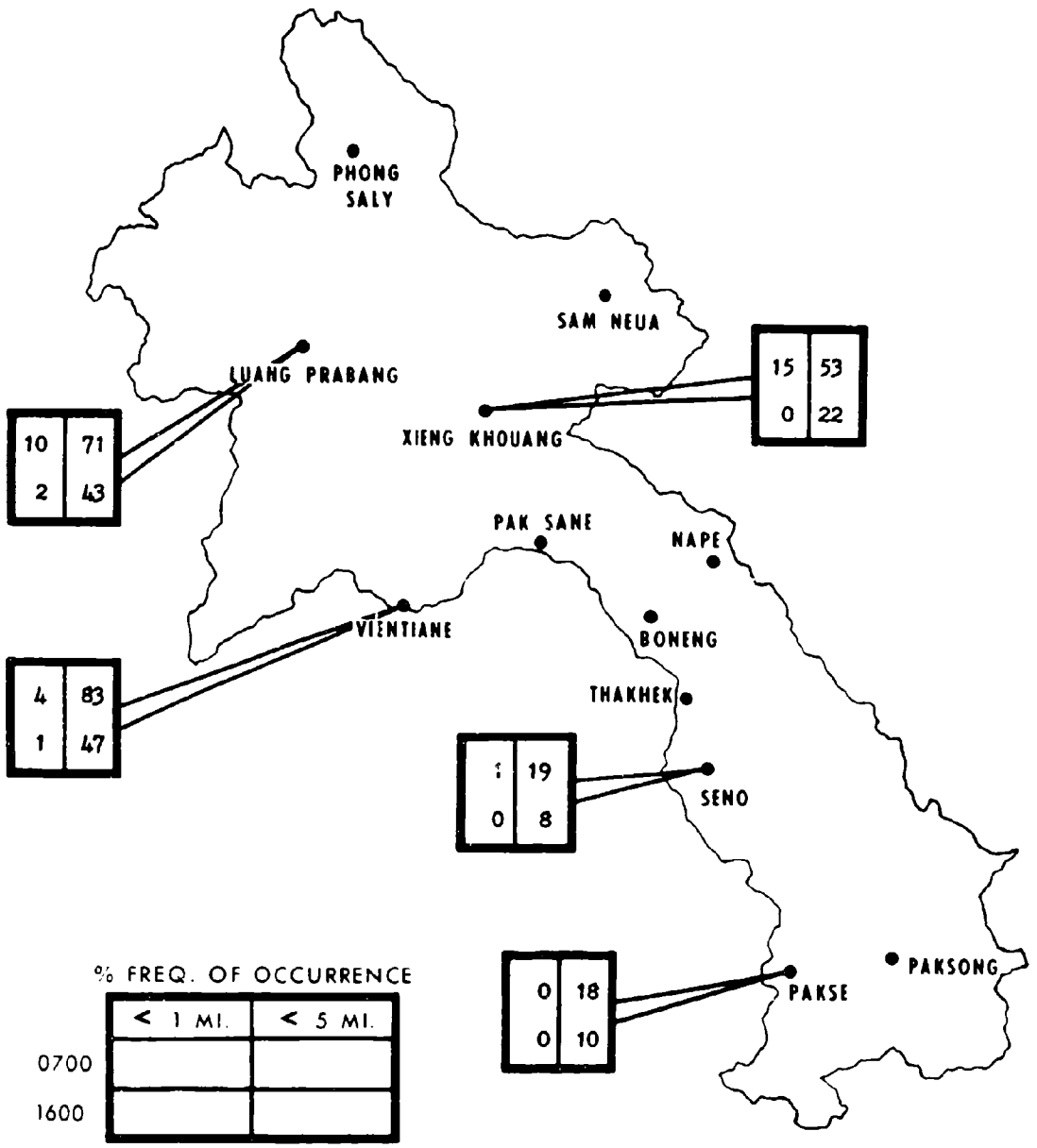


Fig. 11c.

MAR

VISIBILITY



% FREQ. OF OCCURRENCE

	< 1 MI.	< 5 MI.
0700		
1600		

Fig. 12c.

MAR

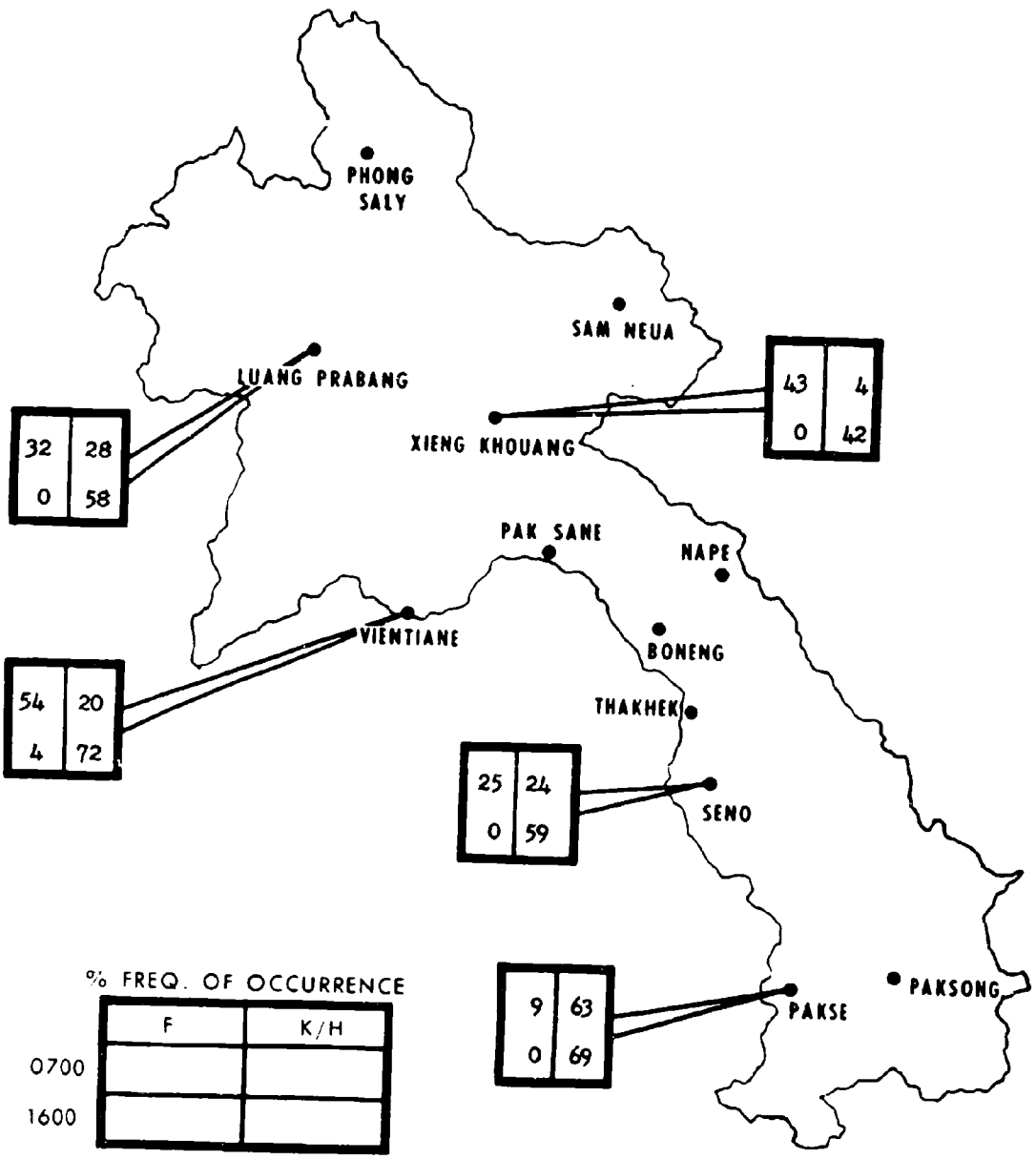

FOG-SMOKE/HAZE
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
PAKSE
32 28
0 58
43 4
0 42
54 20
4 72
25 24
0 59
9 63
0 69
% FREQ. OF OCCURRENCE
F
K/H
0700
1600
MAR

Fig. 13c.

CEILING/VISIBILITY

(0700 LST)

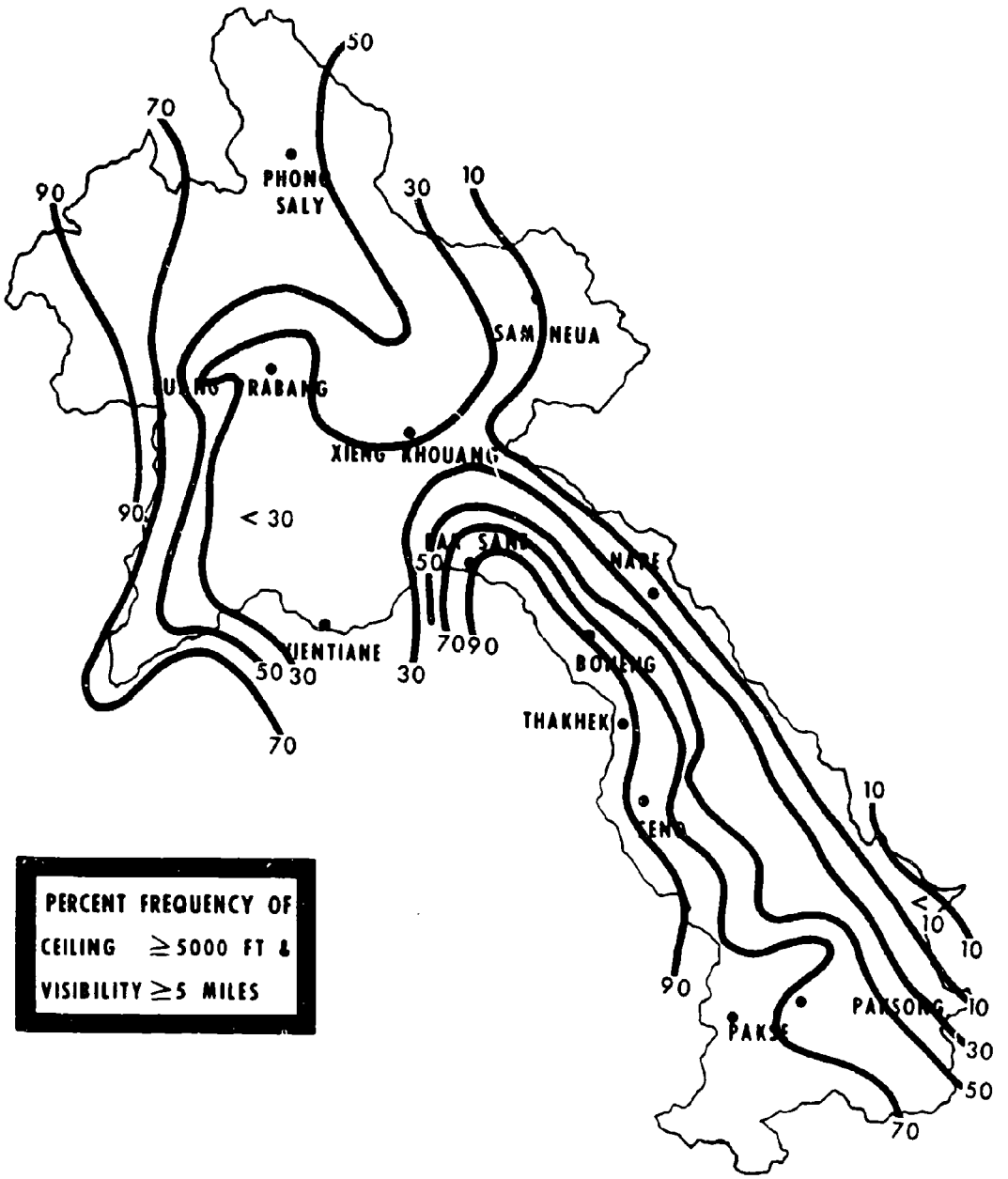


Fig. 14c

MAR

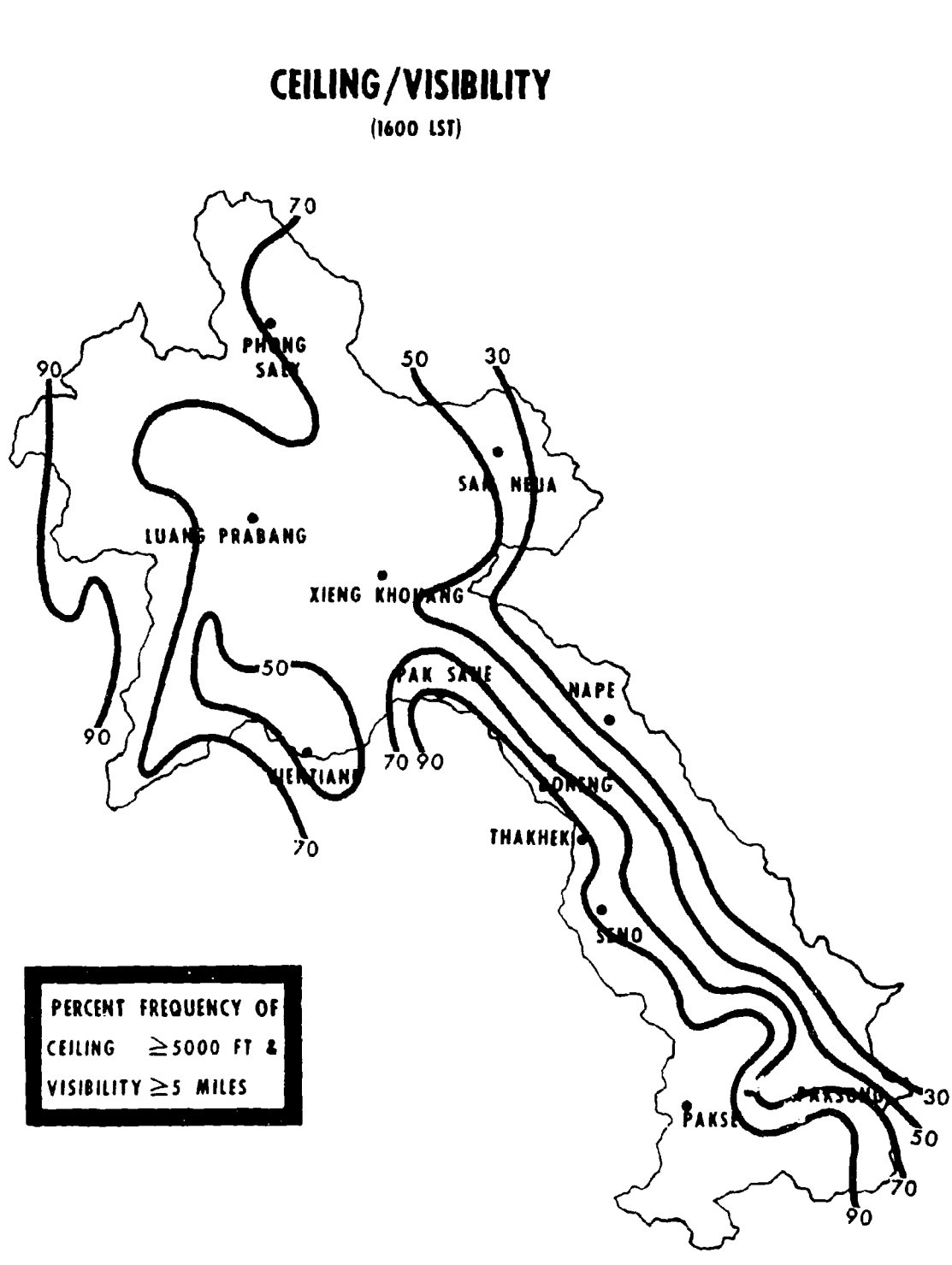
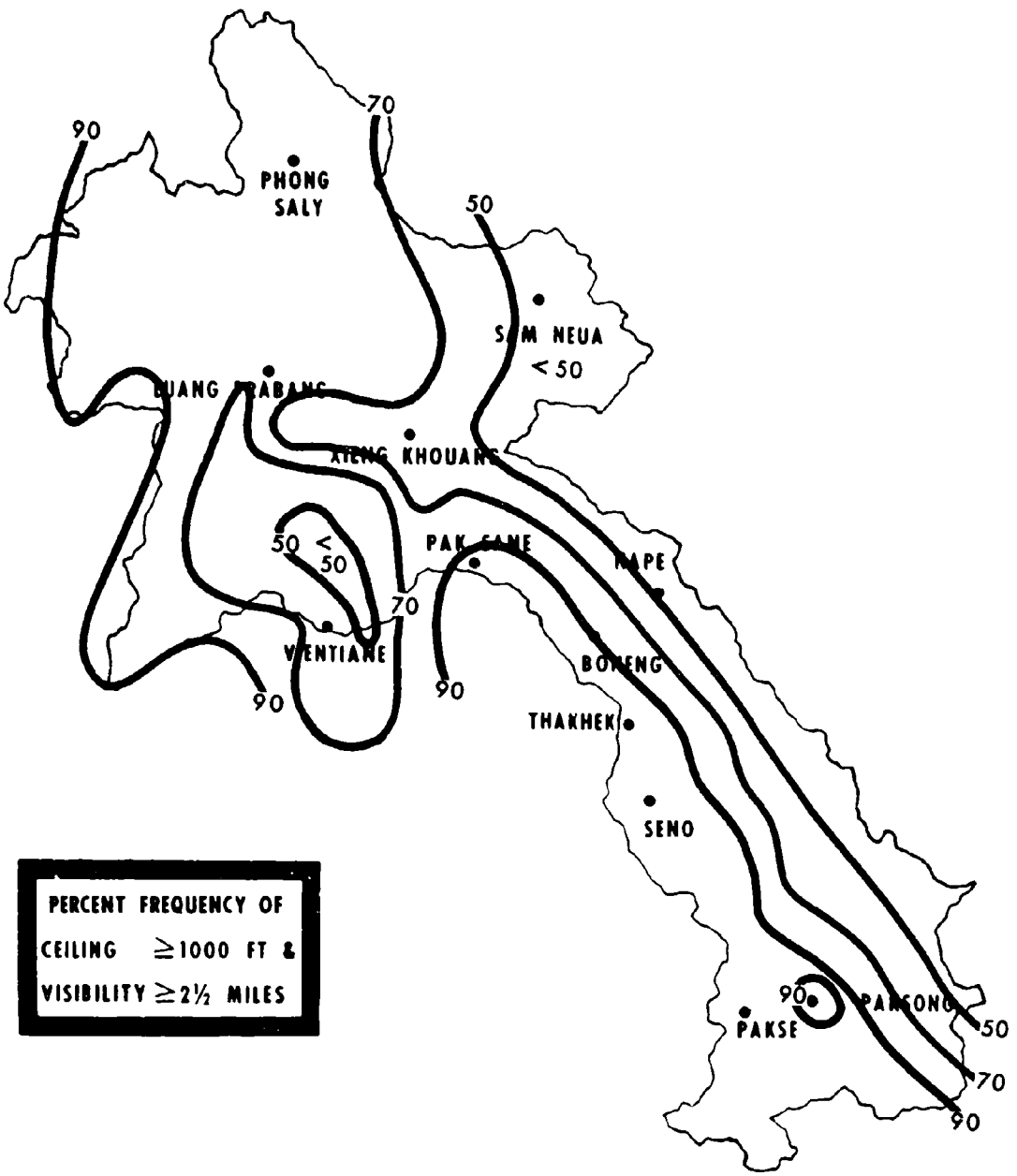

CEILING/VISIBILITY
(1600 LST)
70
90
50
30
LUANG PRABANG
XIENG KHOUANG
50
90
70 90
70
NAPE
THAKHEK
90
50
70
90
PERCENT FREQUENCY OF
CEILING ≥5000 FT &
VISIBILITY ≥5 MILES
MAR

Fig. 15c

CEILING/VISIBILITY

(0700 LST)



PERCENT FREQUENCY OF
CEILING ≥1000 FT &
VISIBILITY ≥2½ MILES

Fig. 16c

MAR

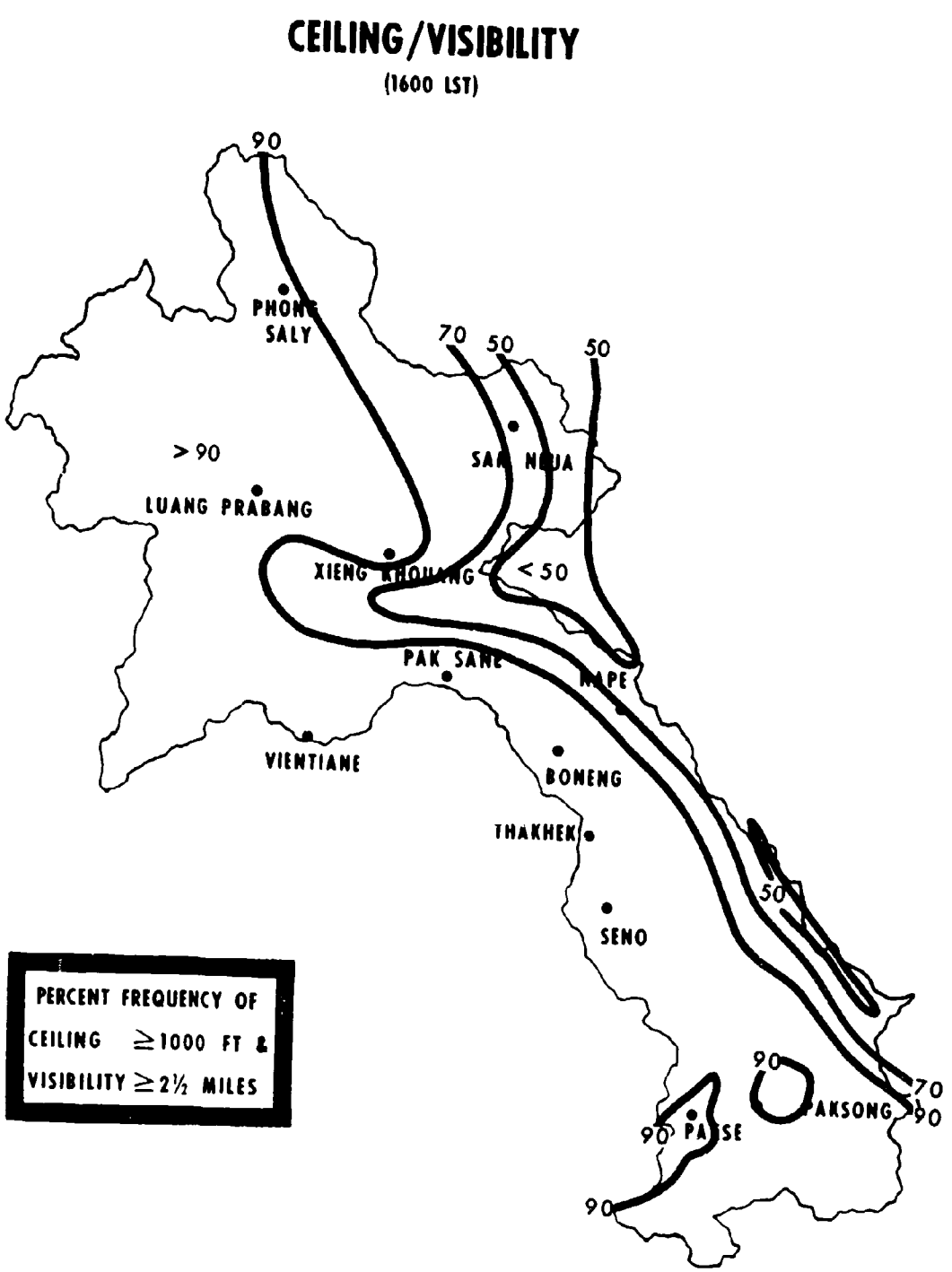

CEILING/VISIBILITY
(1600 LST)
90
PHONG SALY
70
50
50
> 90
LUANG PRABANG
< 50
PAK SANE
MAPE
VIENTIANE
BONENG
THAKHEK
50
SENO
90
70
90
90
90
PERCENT FREQUENCY OF
CEILING ≥1000 FT &
VISIBILITY ≥2½ MILES
MAR

Fig. 17c

MARCH SUNRISE, SUNRISE AND TWILIGHT FOR VIENTIANE (17°59'N, 102°34'E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0542	0607	0629	1816	1838	1903	0.6	-0.6
2	0541	0606	0628	1816	1838	1903	0.5	-0.5
3	0540	0606	0628	1816	1838	1904	0.5	-0.5
4	0540	0605	0627	1817	1838	1904	0.5	-0.5
5	0539	0604	0626	1817	1839	1904	0.4	-0.4
6	0538	0604	0625	1817	1839	1904	0.4	-0.4
7	0538	0603	0625	1817	1839	1905	0.4	-0.4
8	0537	0602	0624	1818	1840	1905	0.3	-0.3
9	0536	0601	0623	1818	1840	1905	0.3	-0.3
10	0535	0601	0622	1818	1840	1905	0.3	-0.3
11	0535	0600	0622	1818	1840	1906	0.2	-0.2
12	0534	0559	0621	1819	1840	1906	0.2	-0.2
13	0533	0558	0620	1819	1841	1906	0.2	-0.2
14	0532	0558	0619	1819	1841	1906	0.1	-0.1
15	0532	0557	0619	1819	1841	1906	0.1	-0.1
16	0531	0556	0618	1820	1841	1907	0.1	-0.1
17	0530	0555	0617	1820	1842	1907	0.0	0.0
18	0529	0554	0616	1820	1842	1907	0.0	0.0
19	0528	0554	0615	1820	1842	1907	0.0	0.0
20	0528	0553	0615	1821	1842	1908	0.0	0.0
21	0527	0552	0614	1821	1843	1908	0.0	0.0
22	0526	0551	0613	1821	1843	1908	0.0	0.0
23	0525	0550	0612	1821	1843	1908	-0.1	0.1
24	0524	0550	0611	1821	1843	1908	-0.1	0.1
25	0523	0549	0611	1822	1843	1909	-0.1	0.1
26	0523	0548	0610	1822	1844	1909	-0.2	0.2
27	0522	0547	0609	1822	1844	1909	-0.2	0.2
28	0521	0546	0608	1822	1844	1909	-0.2	0.2
29	0520	0545	0607	1822	1844	1910	-0.3	0.3
30	0519	0545	0606	1823	1844	1910	-0.3	0.3
31	0518	0544	0606	1823	1845	1910	-0.3	0.3

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 18c.

D. APRIL

1. Climatic Brief: By April the force of the northeast monsoon has dissipated. The large cold Siberian high pressure cell weakens considerably and is displaced further north. The warm Pacific high remains weak, with little buildup or westward movement. The Intertropical Convergence Zone (ICZ) is still south of the country approaching southern Thailand. Thus, the general flow pattern over Laos is weak and variable. April may be considered a transition month between the dry air of the northeast monsoon and the moist air of the southwest monsoon that will affect the weather from May until October. During this month all regions of the country experience similar weather, and thunderstorms and rainshowers become the predominant features of the climate.

Cloudiness during April increases everywhere west of the Annam Range, and decreases everywhere east of it. Mean cloud cover varies from 30 to 60%. The few occurrences of low ceilings are usually associated with thunderstorms. Visibility improves throughout the country as the haze and smoke problem is alleviated by the increased rainfall.

Rainshowers and thunderstorms are quite common. Some thunderstorms, apparently associated with traveling disturbances in the upper westerlies, are extremely violent. These are generally accompanied by low ceilings, heavy precipitation and strong gusty surface winds. They generally last for only an hour or two at any given location. Throughout the country there is a sharp increase in precipitation amounts and frequency of precipitation.

Temperatures reach their annual maximum and extremes as high as 113F have been recorded. With the appearance of southwesterly winds, relative humidities increase everywhere.

2. Temperatures: Over most of the country April is the warmest month of the year. No temperature data are available for northwestern Laos; however, available data from neighboring countries indicate that maximum temperatures in this region average between 75 and 85F. Mean maximum temperatures in the northeastern section and along the eastern border of the panhandle are in the low and mid 80's while those along the Thai border of the panhandle are in the low 90's. The highest mean maximum is 95F at several reporting stations, and the extreme maximum temperature is 113F at Luang Prabang.

Mean daily minimum temperatures range from 60F in the northern mountains to about 75F in the extreme south of the country. The lowest reported mean minimum is 60F at Xieng Khouang (elevation 3760 ft), 100 mi north-northeast of Vientiane. The highest mean minimum is 76F at Pakse. The extreme low temperature on record is 45F at Xieng Khouang. (See Fig. 7d.)

3. Relative Humidity: Relative humidity is generally high throughout the country resulting in conditions favorable for mildew, corrosion, and decay of susceptible items. The high humidity tends to make the high temperature seem even higher.

With the return of the southwesterly winds in April, the relative humidity increases gradually everywhere over Laos. Mean April humidities range from 64% at Pakse to 70% at Luang Prabang. The record low humidity is 15% at Vientiane. (See Fig. 8d.)

4. Precipitation and Thunderstorms: Rainfall increases everywhere as surges of the southwest monsoon appear over Southeast Asia. Most Precipitation is associated with afternoon and evening showers or thunderstorms. There is considerable variation in April rainfall from one year to the next throughout the whole country. Rainless, or near rainless, Aprils have occurred over most regions. The principal factor influencing precipitation amounts, other things being equal, is exposure to the moist wind flow. Sheltered locations, particularly to the lee of the mountain ridges, can expect considerably less rainfall than windward locations. Exposed higher locations, 3,000 to 5,000 ft, can expect greater rainfall than valley locations. It is likely that precipitation records cited in this chapter have been exceeded at non-observing locations. Rainfall is generally light, but 1 or 2 days with precipitation in excess of 1 in. can be expected at most locations. Daily rainfall in excess of 2 in. is uncommon. Precipitation occurs on 4 to 9 days over all areas except on the Plain of Jarres and Bolovens Plateau. Rain is observed on 10 to 14 days in these regions. Mean monthly precipitation amounts vary from 2 to 3 in. in the northwestern mountains to 8 in. at Vang Vieng, 60 mi north of Vientiane.

Maximum April rainfall amounts range from about 6 in. in the central panhandle to more than 20 in. on windward slopes south of the Plain of Jarres. Vang Vieng has an April rainfall of 32 in. Minimum values are less than 1 in. over most of the country, but minimums in the area around Pak Song are 2 to 3 in. The highest observed 24-hr rainfall is 6.1 in. at Vientiane, but maximum one day values over Laos generally range between 3 and 5 in.

During April, thunderstorm activity increases rapidly to become a prominent climatic feature. Low-level winds become more southerly and carry warm, moist air far inland, where it is further heated by the sun. When cool, dry northerly air overrides this warm low-level air, extreme instability occurs, causing violent afternoon and evening thunderstorms. Northern Laos observes thunderstorms on 4 to 6 days. Stations along the Thai border and in the panhandle experience thunderstorms on 10 to 13 days. (See Figs. 9d, 10d and 11d.)

5. Cloudiness: With the continued weakening of the northeast monsoon and the appearance of surges of the southwest monsoon, cloudiness increases over most of the country. Convective clouds, with bases 2,000

to 4,000 ft, form during the morning. By the end of the month, early afternoon ceilings become common.

Mean cloudiness in the northern portion varies from 30% over western mountains to 60% over the southern panhandle. The occurrence of widely scattered clouds (days with not more than 3/10 cloud cover) varies from 5 to 6 days along the Vietnam border to about 15 days along much of the Thailand border.

6. Visibility and Obstructions to Vision: In April there is a noticeable decrease in the incidence of obstructions to vision such as haze, smoke and fog, and in consequence, an increase in visibility. Nevertheless, visibilities remain relatively poor in valley fogs in the northern mountains during the early morning hours. Upper air visibility is reduced occasionally to less than 3 mi by smoke and haze from grass, brush, and forest fires, as well as from slash-and-burn farming techniques, but the occurrence of these restrictions decreases as the increasing rainfall heralds the approach of the southwest monsoon. In general, surface visibility is best during the afternoon and slant range visibility is best between 0800 and 1100 LST. Visibilities of greater than 12 mi are not common anywhere over Southeast Asia.

In early April, as smoke and haze contaminate the lower atmosphere, daytime visibilities of less than 5 mi are frequent. Later in April, as shower activity increases and rainfall inhibits smoke sources, the visibility improves rapidly. Nevertheless, slant range visibility remains poor as afternoon convective cloudiness increases.

The occurrence of fog, haze and smoke, decreases throughout Laos during April. Radiation fog is most likely in river valleys and most prevalent and persistent in deep, steep-walled valleys. Morning visibilities of less than 3 mi occur occasionally in morning river valley fog. Fog generally forms during predawn hours and dissipates by 0900 LST, but in deeper valleys it may form earlier and persist longer. It is highly likely that fog forms more frequently in the mountain river valleys of northern Laos than indicated by the figures presented here. Fog can be expected on less than 5 days over most of Laos. Fog occurs on 6 to 12 days in the region between Luang Prabang and Vientiane. (See Figs. 12d and 13d.)

7. Wind and Temperatures Aloft: During April the mean flow over Laos continues to become more southerly as the change from northeast monsoon circulation to southwest monsoon takes place. Because April is a transitional month between the northeast and southeast monsoonal seasons, wind directions are variable and may differ considerably from mean streamlines. Local surface winds, directions and speeds, are influenced by local topography and can deviate significantly from mean winds. Wind speeds, in general, are light. Easterly flow in the lower atmosphere is weakening and is being replaced by southerly flow. Although flow in the higher atmosphere changes little from that of the northeast monsoon season, upper westerlies continue to penetrate to lower levels and merge with the low-level southwesterly flow.

In the vertical, temperature decreases approximately 3.3F for every 1,000 ft in the lower atmosphere. The mean height of the freezing level varies from 16,000 ft in the north to 16,500 ft in the south, but the actual height may be found to vary as much as 2,000 ft from the mean levels. At 25,000 ft the air temperature is close to -18C.

8. Combined Ceiling and Visibility: Ceilings and visibilities are poorest during the early morning hours near sunrise with visibilities the major restrictant. Ceilings of 5000 feet or more accompanied by visibilities of at least 5 miles ($\geq$5000/5) occur less than 10% of the time along the crest of the Chaine Annamatique on the eastern border. Over a large portion of the northern half of the country they occur less than 30% of the time. Only along portions of the Mekong Valley does the frequency reach as high as 90%. Between early morning and mid-afternoon there is a general overall improvement in the areas of lower frequency: $\geq$5000/5 occurs at least 30% of the time on the crest of the Chaine Annamatique and more than 50% of the time over most of the country. The Mekong Valley continues to be the best region with a frequency near 90%.

The frequency of $\geq$1000/2 1/2 is also at a minimum during the early morning hours and is somewhat less than 50% along most of the eastern border region. Over most of the Mekong Valley and the western border of northern Laos the frequency exceeds 90%. Considerable improvement in the areas of low frequency generally takes place by mid-afternoon. Most of the crest of the Chaine Annamatique has frequencies in the range 50 to 70%. More than half the country has a frequency greater than 90%. (See Figs. 14d, 15d, 16d and 17d.)

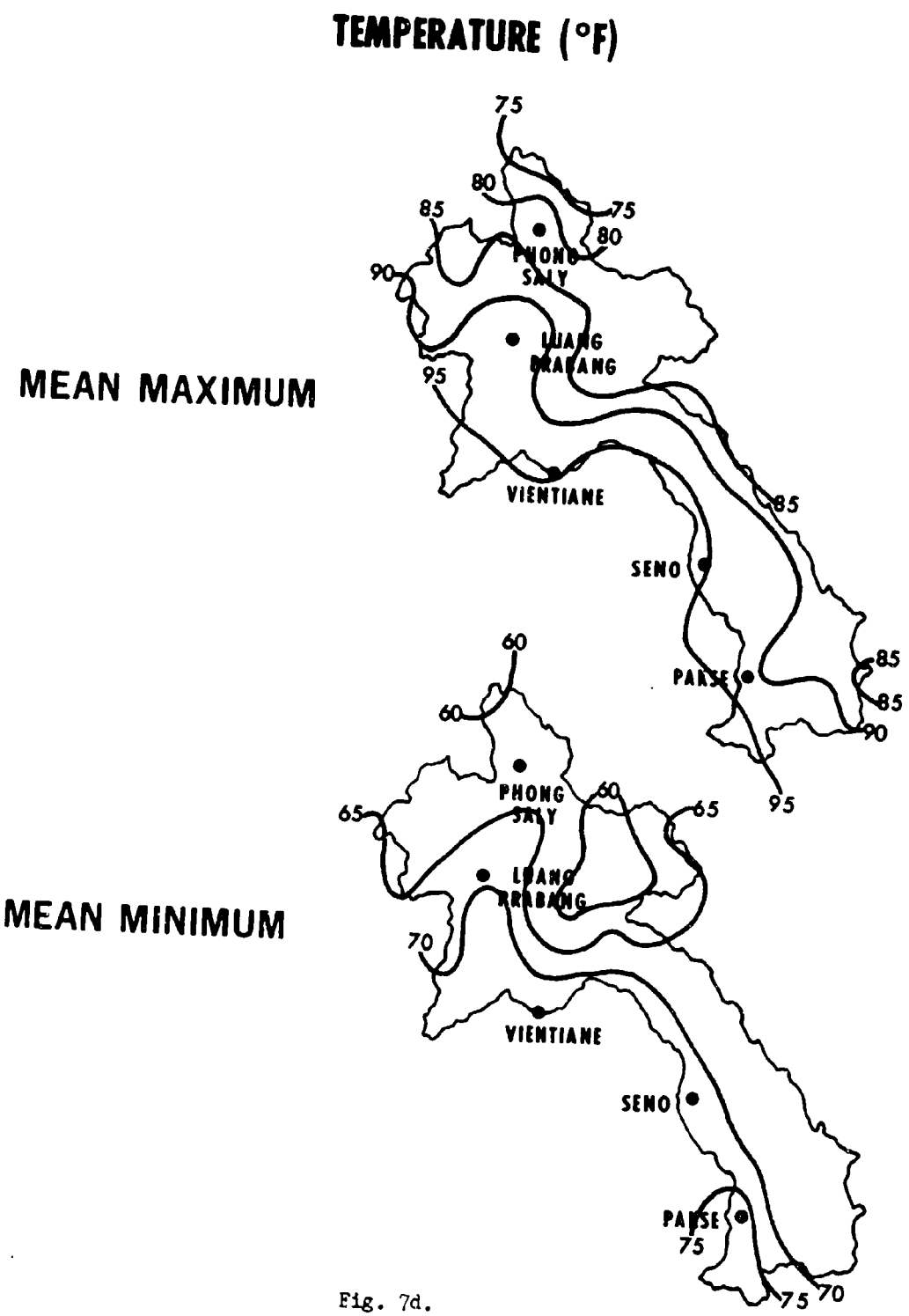

TEMPERATURE (°F)
MEAN MAXIMUM
MEAN MINIMUM
75
80
85
75
80
90
PHONG SALY
LUANG PRABANG
95
VIENTIANE
85
SENO
60
85
PAKSE
85
60
90
60
PHONG SALY
65
60
65
95
LUANG PRABANG
70
VIENTIANE
SENO
PAKSE
75
75
70
APR

Fig. 7d.

MEAN RELATIVE HUMIDITY (%)

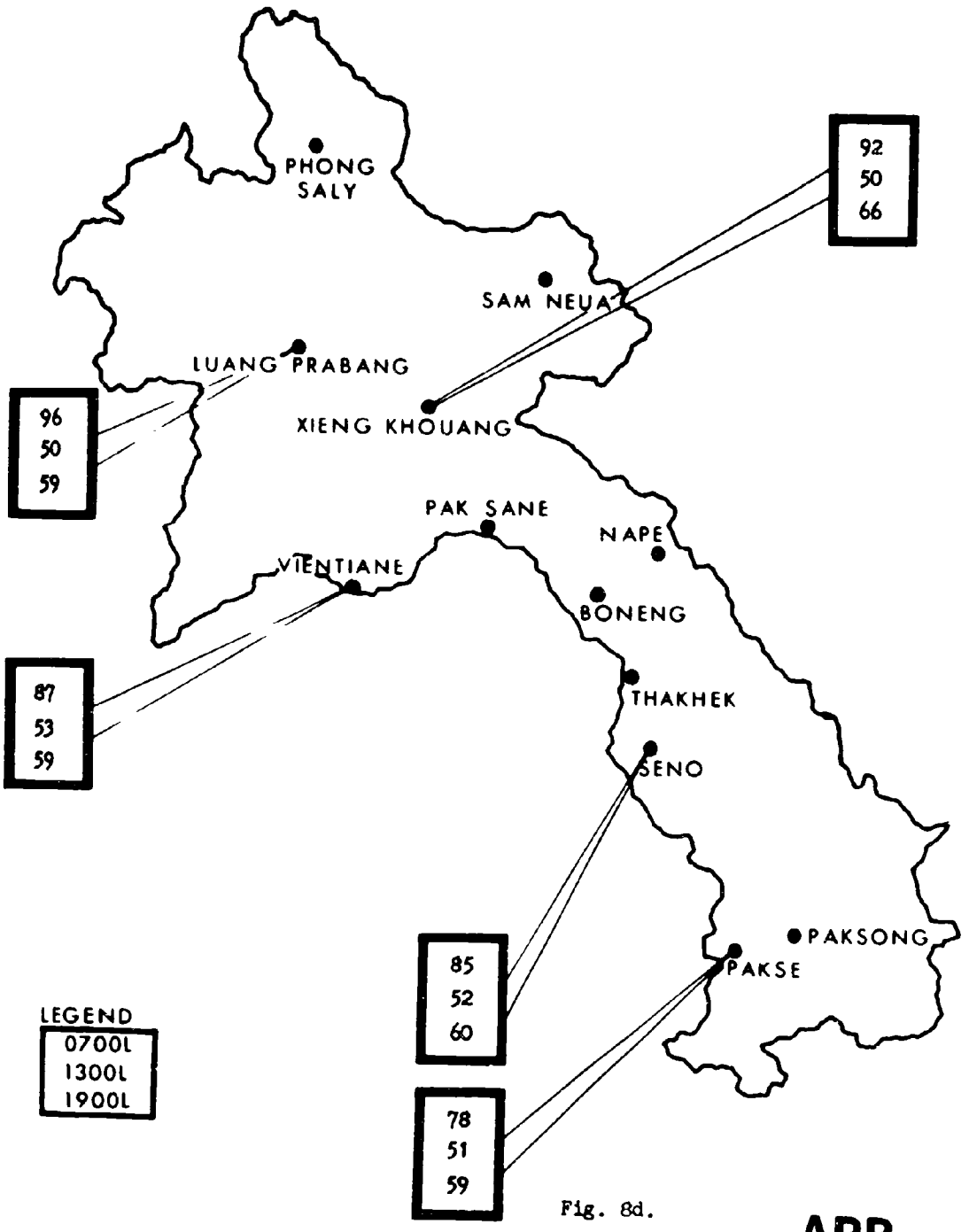


Fig. 8d.

APR

MEAN NUMBER OF DAYS WITH PRECIPITATION

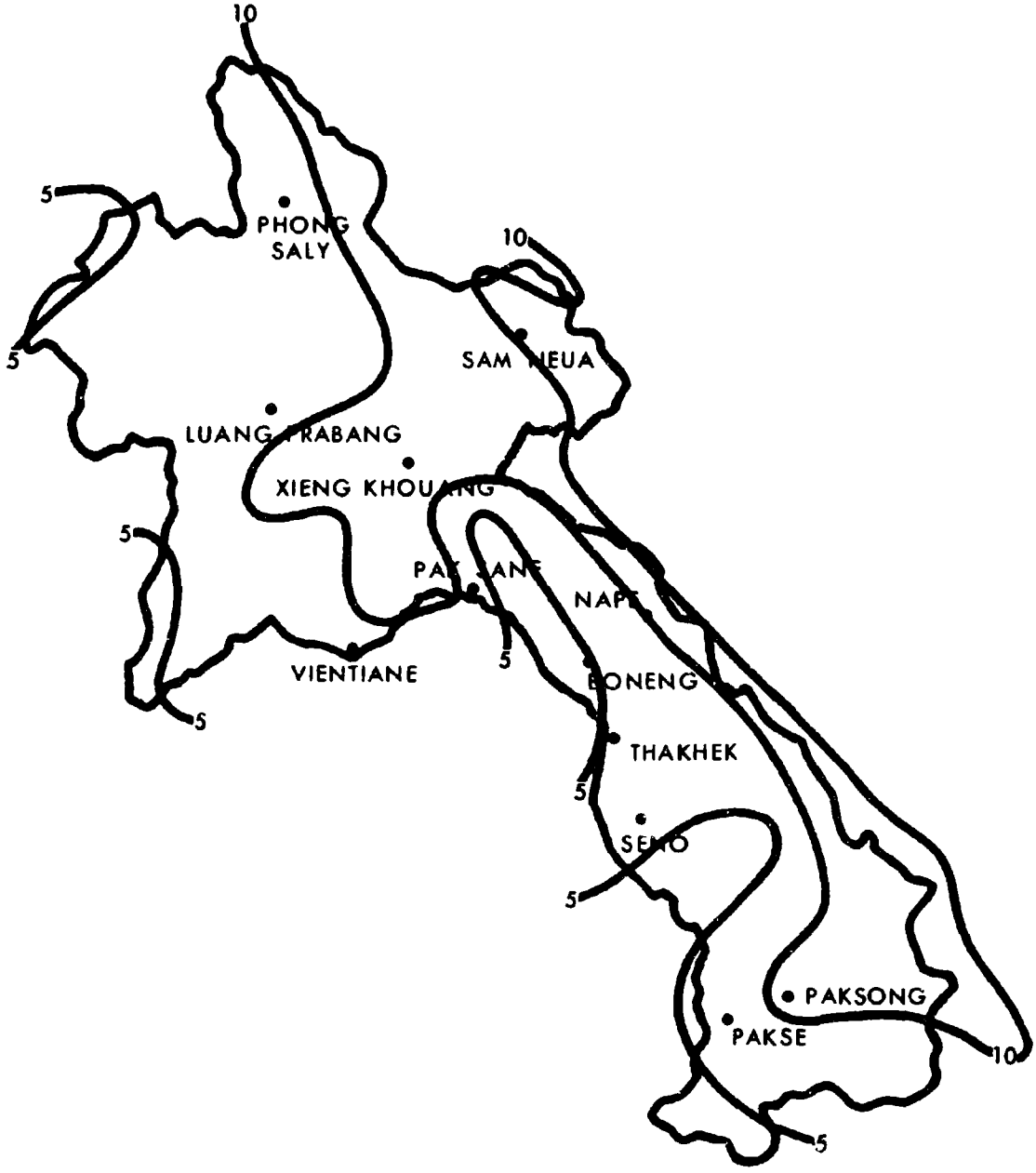


Fig. 9d.

APR

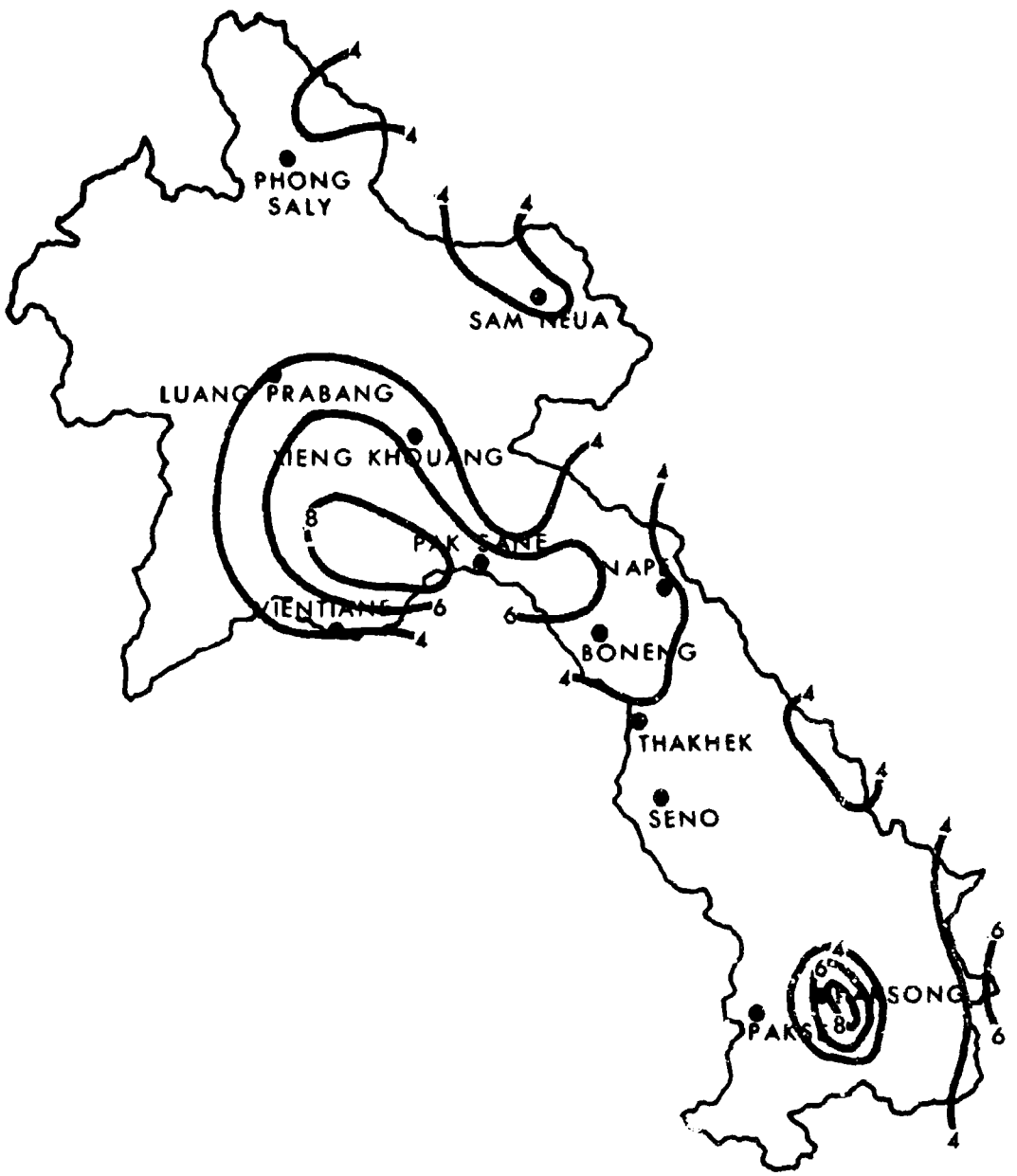

MEAN PRECIPITATION (in)
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
APR

Fig. 10d

PRECIPITATION and THUNDERSTORMS

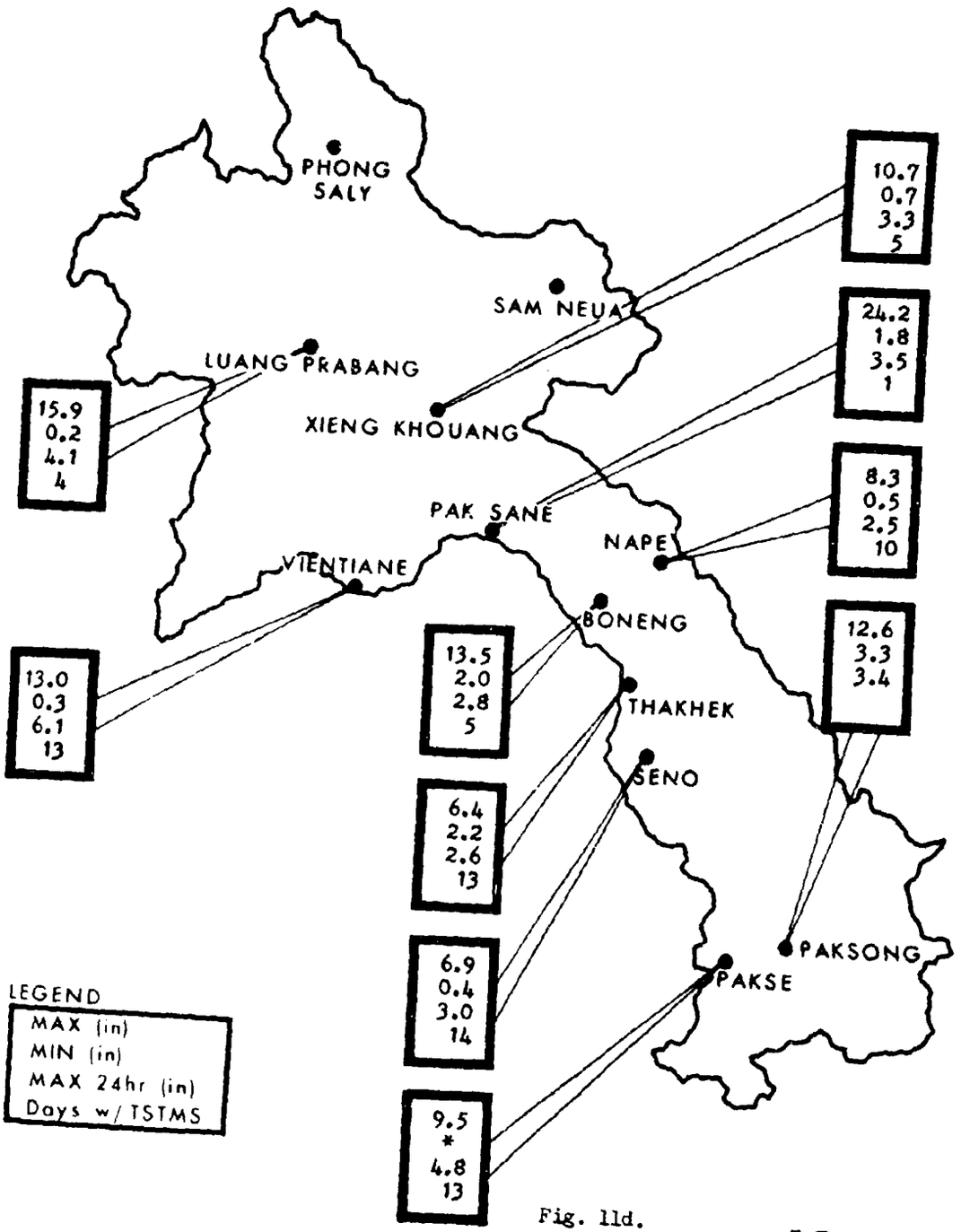


Fig. 11d.

APR

VISIBILITY

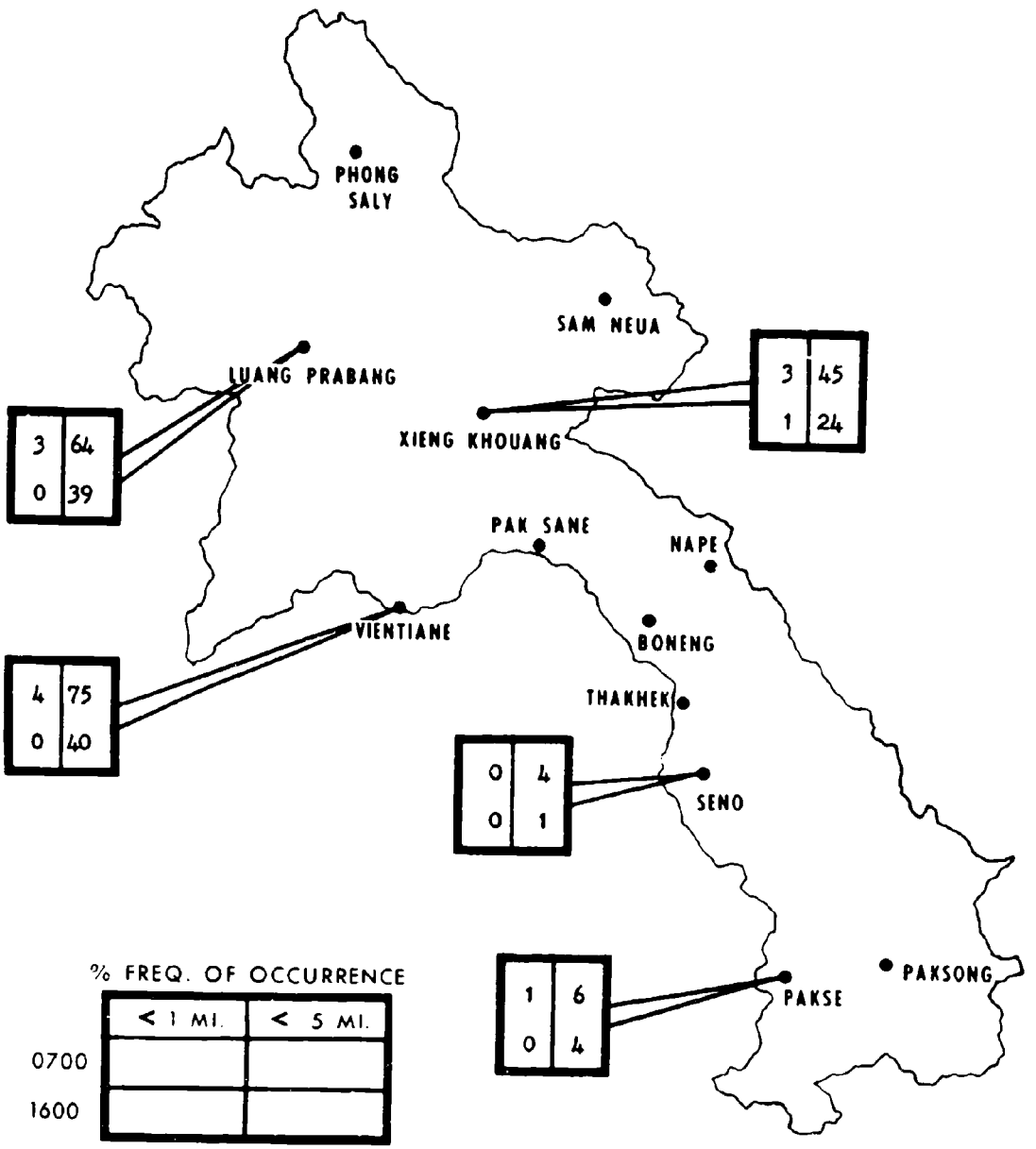


Fig. 12d.

APR

FOG-SMOKE/HAZE

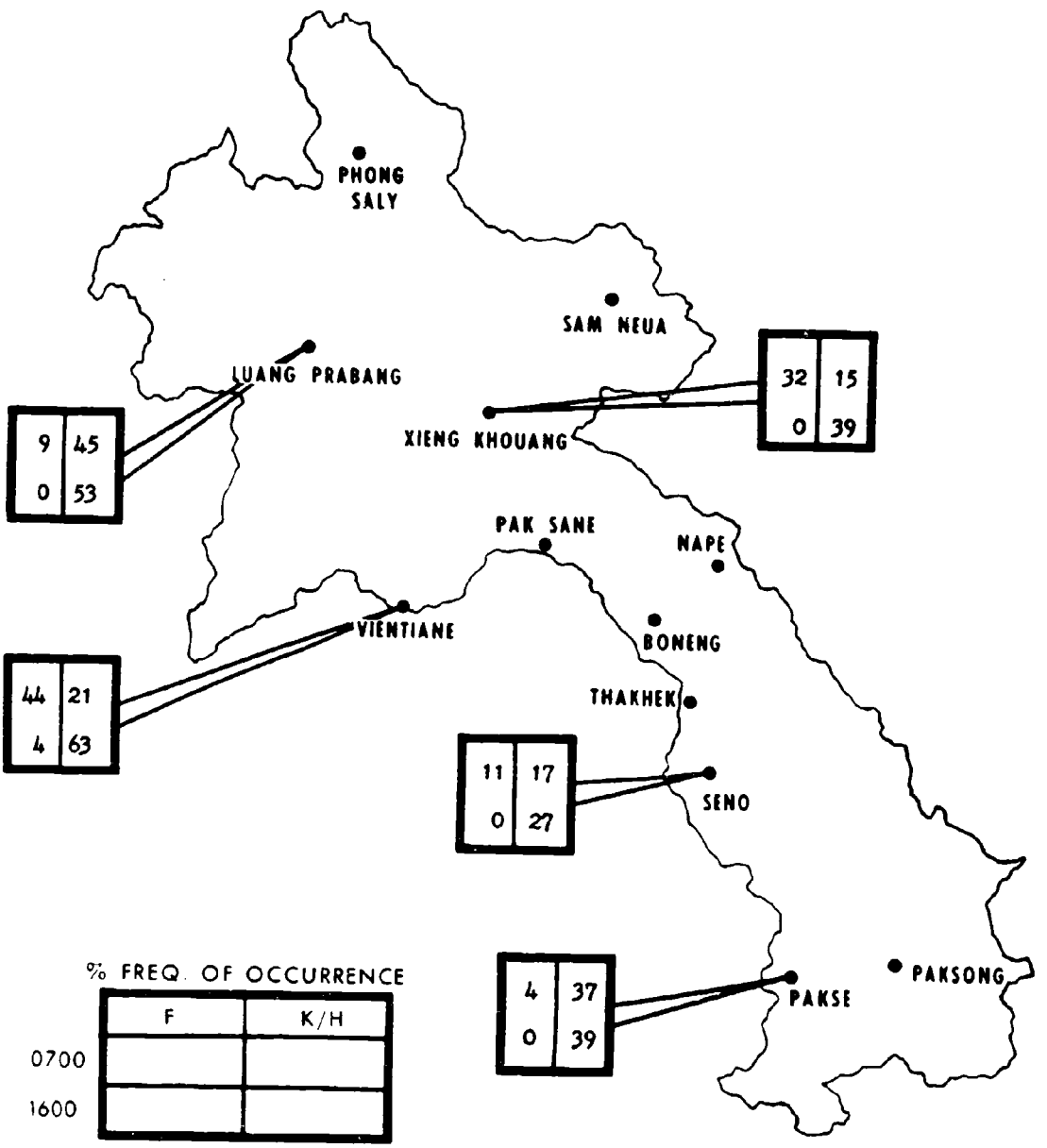


Fig. 13d.

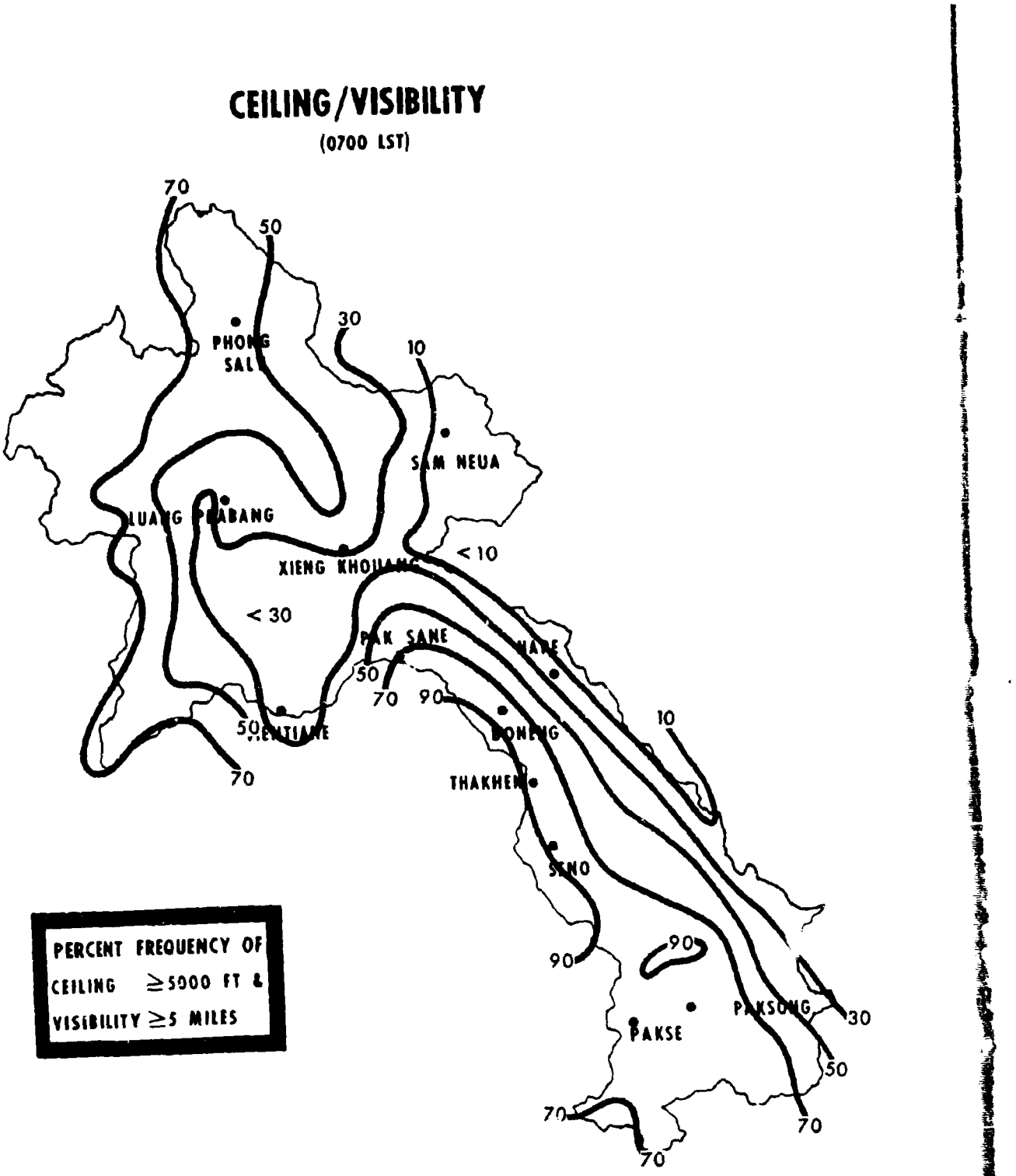

CEILING/VISIBILITY
(0700 LST)
70
50
30
10
PHONG SALI
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
< 10
< 30
PAK SANE
50
70
90
50
70
10
THAKHEK
SENO
90
90
PAKSONG
30
PAKSE
50
70
70
70
PERCENT FREQUENCY OF
CEILING ≥5000 FT &
VISIBILITY ≥5 MILES
APR

Fig. 11d

CEILING/VISIBILITY

(1600 LST)

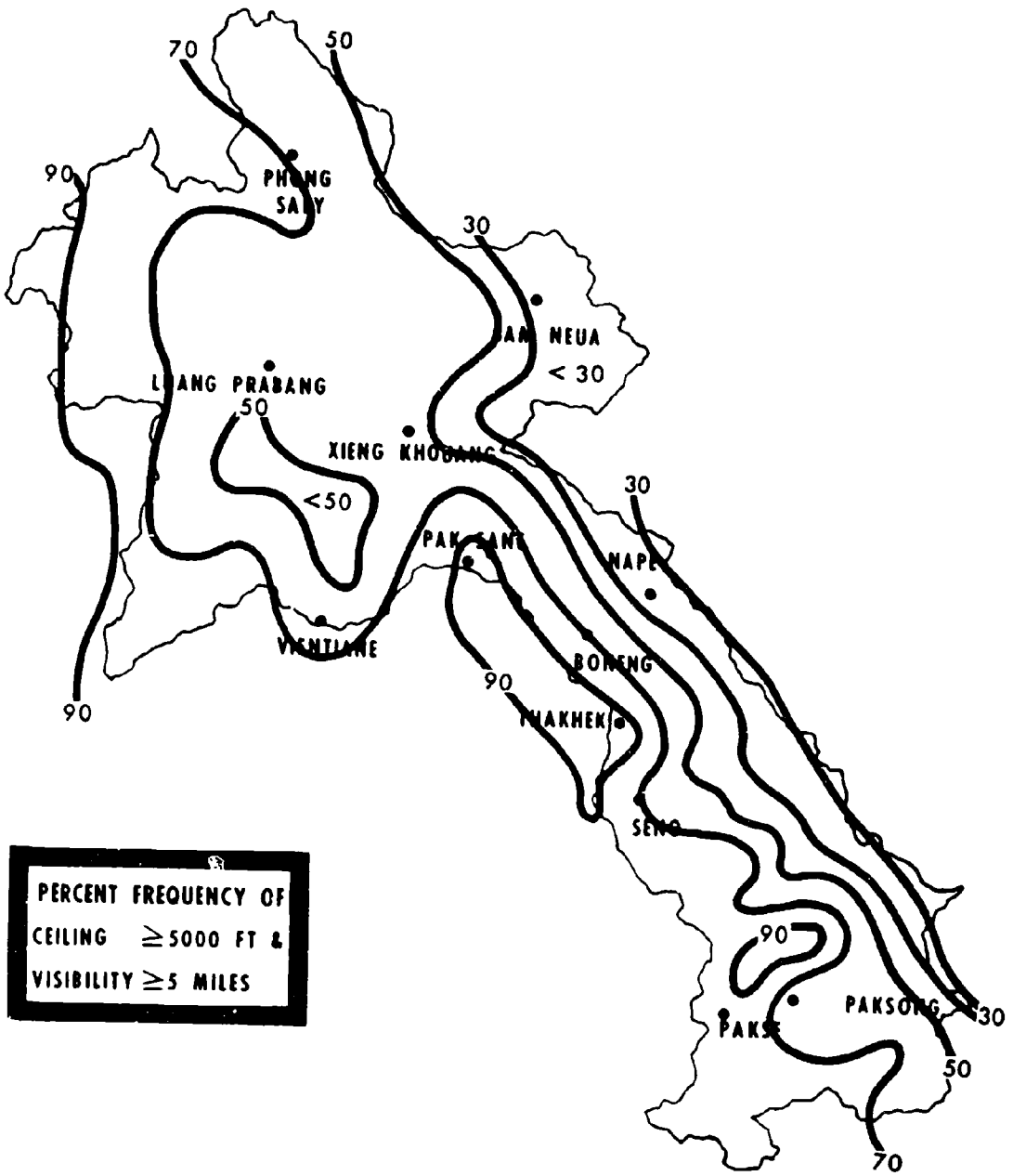
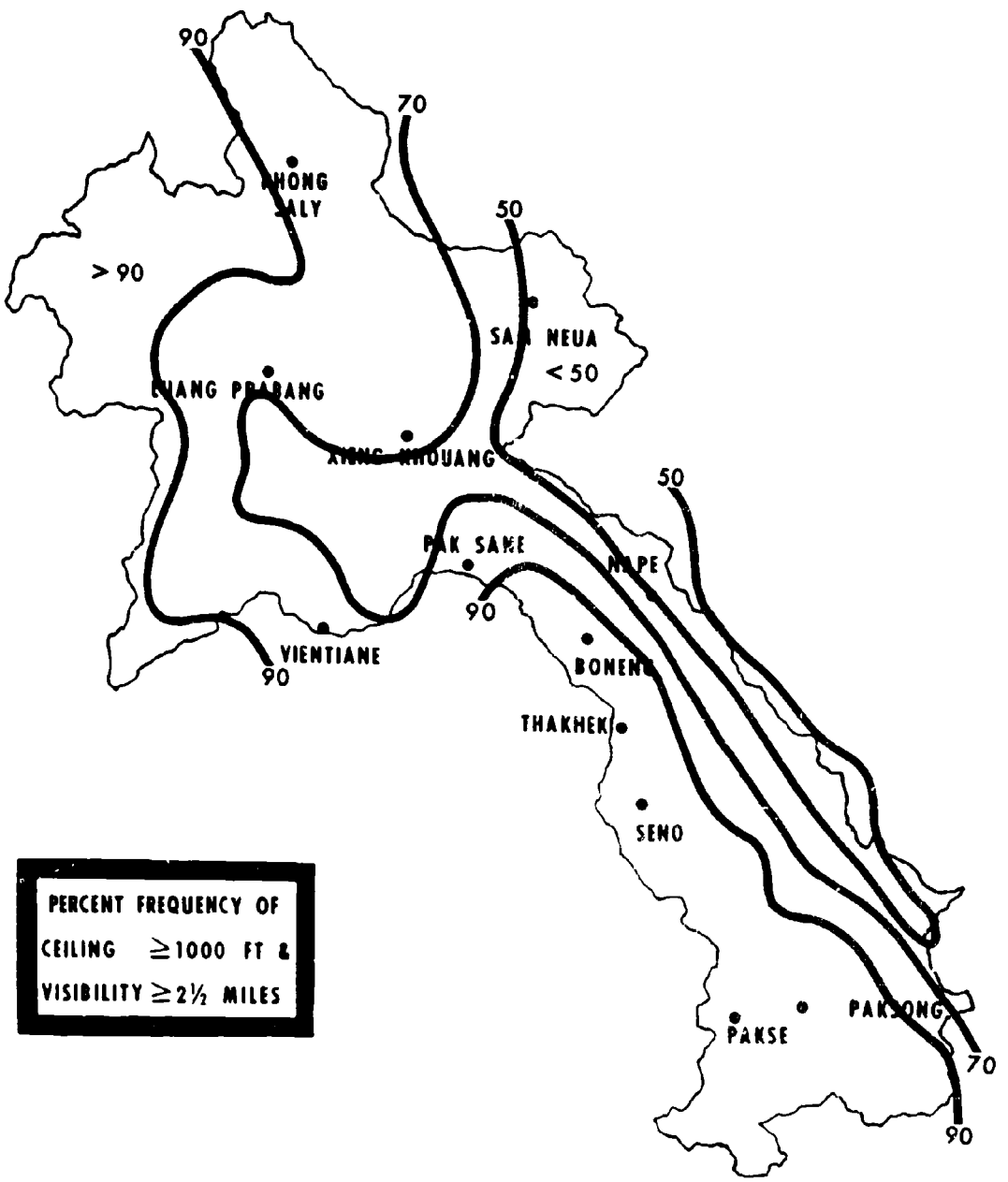


Fig. 15d

APR

CEILING/VISIBILITY

(0700 LST)



PERCENT FREQUENCY OF
CEILING ≥1000 FT &
VISIBILITY ≥2½ MILES

Fig. 16d

APR

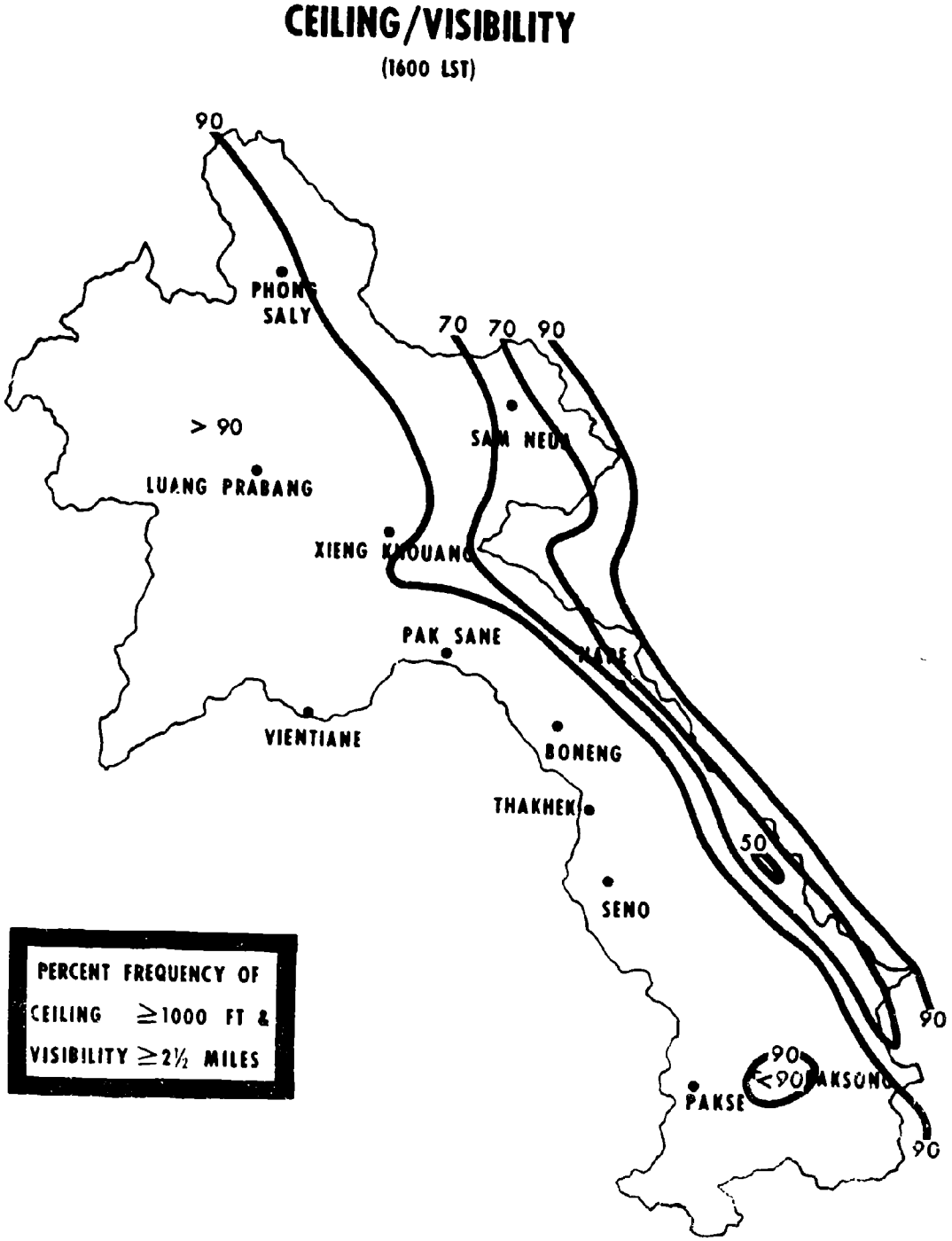

CEILING/VISIBILITY
(1600 LST)
90
PHONG SALY
70 70 90
> 90
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
VIENTIANE
BONENG
THAKHEK
50
SENO
90
90
<90
PAKSE
90
PERCENT FREQUENCY OF
CEILING ≥1000 FT &
VISIBILITY ≥2½ MILES
APR

Fig. 17d

APRIL SUNRISE, SUNSET AND TWILIGHT FOR VIENTIANE (17°59'N, 102°34'E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0518	0543	0605	1823	1845	1910	-0.4	0.4
2	0517	0542	0604	1823	1845	1911	-0.4	0.4
3	0516	0541	0603	1823	1845	1911	-0.4	0.4
4	0515	0541	0602	1824	1846	1911	-0.5	0.5
5	0514	0540	0602	1824	1846	1911	-0.5	0.5
6	0513	0539	0601	1824	1846	1912	-0.5	0.5
7	0513	0538	0600	1824	1846	1912	-0.6	0.6
8	0512	0537	0559	1825	1847	1912	-0.6	0.6
9	0511	0537	0558	1825	1847	1912	-0.6	0.6
10	0510	0536	0558	1825	1847	1913	-0.6	0.7
11	0509	0535	0557	1825	1847	1913	-0.7	0.7
12	0508	0534	0556	1825	1848	1913	-0.7	0.7
13	0508	0533	0555	1826	1848	1914	-0.7	0.7
14	0507	0533	0555	1826	1848	1914	-0.7	0.8
15	0506	0532	0554	1826	1848	1914	-0.8	0.8
16	0505	0531	0553	1826	1849	1915	-0.8	0.8
17	0504	0530	0553	1827	1849	1915	-0.8	0.8
18	0504	0530	0552	1827	1849	1915	-0.9	0.9
19	0503	0529	0551	1827	1849	1916	-0.9	0.9
20	0502	0528	0550	1827	1850	1916	-0.9	0.9
21	0501	0527	0550	1828	1850	1916	-0.9	0.9
22	0500	0527	0549	1828	1850	1917	-1.0	1.0
23	0500	0526	0548	1828	1851	1917	-1.0	1.0
24	0459	0525	0548	1828	1851	1917	-1.0	1.0
25	0458	0525	0547	1829	1851	1918	-1.1	1.1
	0458	0524	0546	1829	1852	1918	-1.1	1.1
	0457	0523	0546	1829	1852	1918	-1.1	1.1
28	0456	0523	0545	1830	1852	1919	-1.1	1.2
29	0455	0522	0545	1830	1853	1919	-1.2	1.2
30	0455	0521	0544	1830	1853	1920	-1.2	1.2

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 18d.

E. MAY

1. Climatic Brief: The transition from the dry northeast monsoon to the moist southwest began in April and is completed over all of Laos by the end of May. The airstreams that comprise the southwest monsoon originate in the semi-permanent high pressure cells over Australia and the India Ocean. The stream of air originating in Australia is warm, stable and very dry. It is rapidly modified during its passage over warmer equatorial water, and is very moist and unstable in the lower layers by the time it merges over Sumatra and Malaya with the flow from the Indian Ocean. When the air arrives over Southeast Asia it is distinctly tropical maritime in nature. The flow is strongest between 3,000 and 5,000 ft but may be traced as high as 15,000 ft.

Cloudiness increases during May, and at most locations, cloud cover averages 60 to 80%. In general, low ceilings are associated with shower activity and do not persist at any given location more than an hour or two. Middle and high clouds increase in frequency and coverage, especially west of the Annam Range, and overcast skies are common by the end of the month.

Visibilities continue to improve during May. Occurrences of fog, haze and smoke decrease almost everywhere. Low visibilities occur mainly with showers and thunderstorms.

There is a marked increase in the frequency and intensity of showers and thunderstorms. Thunderstorms occur almost daily at some locations. Some thunderstorms can be particularly violent and may be oriented along squall lines that travel from west to east accompanied by low ceilings, poor visibilities, heavy rain and strong gusty surface winds. Thunderstorms traveling in squall lines generally do not dissipate or lessen in intensity with nightfall as do air mass-thermal type thunderstorms. However, since they are part of a moving system, squall line thunderstorms ordinarily affect a given location for only a few hours at a time.

In general, temperatures decrease slightly during May. With moist, southwesterly winds becoming firmly established by the end of the month, the relative humidity increases everywhere. Mean humidity values range from 75 to 80% over most of the country.

2. Temperatures: Temperatures decrease slowly throughout Laos in May. No temperature data are available for the region north of 20°N; however, available data from neighboring countries indicate that maximum temperatures in this area average between 80 and 90F. Maximums in this temperature range extend southeastward along the Vietnam border to about 60 mi south of Nape, where elevations are under 3,000 ft. Low mean maximum temperatures are found in the highlands around Pak Song in the south. Elsewhere mean maximums are in the low 90's. The highest reported mean maximum is 94F at Luang Prabang (elevation 950 ft). The lowest mean maximum is 77F at Pak Song (elevation 3937 ft), 30 mi east of Pakse. The extreme high temperature is 111F at Luang Prabang.

Mean daily minimum temperatures follow the same pattern as the maximums. Minimums range from 60 to 65F in northern mountains to 75F at Pakse (elevation 305 ft). The lowest reported mean minimum is 64F at Pak Song and Xieng Khouang, 85 mi southeast of Luang Prabang. The extreme low temperature is 57F also at Xieng Khouang. (See Fig. 7e)

3. Relative Humidity: The relative humidity is high throughout Laos, resulting in conditions favorable for mildew, corrosion and decay of susceptible items. The high humidity tends to make the high temperature seem even higher.

With the return of southwesterly low-level winds, relative humidity increases everywhere. Mean humidities range from 75% at Seno to 79% at Luang Prabang and Vientiane. The record low relative humidity is 22% at Luang Prabang and Thakhek, 60 mi north of Seno. (See Fig. 8e)

4. Precipitation and Thunderstorms: May is a wet season month throughout Laos. Rainfall increases everywhere and occurs primarily as afternoon and evening showers or thundershowers. Amounts are generally light, but rainfall in excess of 1 in. can be expected on 1 or 2 days at most locations. However, a daily rainfall in excess of 2 in. is rare. The mean number of days with measurable precipitation ranges from 12 days in the border region west of Vientiane to 22 days at Pak Song.

Mean monthly amounts are less than 10 in. over most of the country, with the exception of the region north and northeast of Vientiane, which ranges from 15 to 20 in. and the Bolovens Plateau in the south, which ranges from 12 to 15 in.

Maximum monthly precipitation amounts range from about 14 in. in the central panhandle to 36 in. at Pak Sane. Minimum monthly rainfalls vary from less than 1 in. in the vicinity of Luang Prabang to 10 in. at Boneng, 100 mi north-northwest of Seno. Maximum 24-hr rainfall values are between 2 and 4 in. over most of Laos. Vientiane and Phong Saly have had one-day rainfalls of 6 in.

In general, thunderstorm activity reaches its annual maximum over most of Laos in May. Thunderstorms can be expected on 7 to 10 days over the northern mountains and Annam Range. Locations along the Mekong River and Thai border observe thunderstorms on an average of 17 to 23 days. (See Fig. 9e, 10e and 11e)

5. Cloudiness: Cloudiness over Laos shows a significant increase during May. Convective clouds form during the late morning hours and ceilings, with bases 2,000 to 3,000 ft are frequent during the afternoon. Mountain tops are frequently obscured as cloud masses build on windward slopes. The frequency of thunderstorm clouds increases everywhere. Broken cloud layers, with bases between 8,000 and 15,000 ft, are associated with afternoon and evening thunderstorms. Nocturnal cloudiness becomes more common

during May, but low ceilings are infrequent. Cirrus clouds above 30,000 ft are common.

Mean cloudiness over the northwestern part of the country is around 60% but over much of the rest of the country averages 70 to 80%. Total cloud cover of 3/10 or less can be expected on 7 days or less over the entire country.

6. Visibility and Obstructions to Vision: With the frequency of fog, haze and smoke decreasing everywhere visibilities continue to improve during May. Daytime visibilities are good as shower activity inhibits smoke sources and reduces haze. Morning visibilites less than 3 mi occur occasionally with fog in river valleys. Radiation fog is most likely in river valleys, and most prevalent and persistent in deep, steep-walled valleys. Fog generally forms during predawn hours and dissipates by 0900 LST, but in deeper valleys, it may form earlier and persist through the morning. It is likely that fog forms more frequently than indicated by data from observing locations in the northern Laotian river valleys. Based on known data, fog occurs on 5 to 6 days in the mountain valleys north of 20°N and in the Annam Range, but elsewhere fog is observed on 3 days or less. Haze and smoke in the Vientiane region frequently reduce the visibility to less than 5 mi from shortly after sunset to about noon. Slant range visibility shows little improvement because convective cloudiness increases as the occurrences of smoke and haze decreases. (See Fig. 12e and 13e.)

7. Wind and Temperatures Aloft: During May, winds shift completely to a southwesterly flow over all of Laos as the southwest monsoon becomes firmly established. In early May, the mean low-level flow shifts from southeasterly to southwesterly, and by late May, when the southwest monsoon becomes firmly established, winds are southwesterly over all of Laos. Winds speeds are generally light. Local surface wind directions and speeds are influenced by local topography, and can deviate significantly from mean winds.

In the lower atmosphere, the easterly flow is gradually replaced by southerly winds, but in the higher atmosphere, there is little change in the flow from that of the northeast monsoon season. North of 20°N latitude upper westerlies continue to penetrate to lower levels and merge with the low-level southwesterly flow, while south of 20°N, southwesterly winds extend up to about 25,000 ft. Above 25,000 ft, a westerly flow prevails to above 40,000 ft. Wind speeds increase northward and upward in these upper westerlies.

Upper air temperatures are close to -18C at 25,000 ft throughout the year. During May, the mean freezing level ranges from 17,000 ft in the north to near 16,500 ft in the south.

8. Combined Ceiling and Visibility: Ceiling and visibilities are poorest during the early morning hours near sunrise with visibilities being the major restrictant. Ceilings of 5,000 ft or more accompanied by visibilities

of at least 5 mi ($\geq$5,000/5) occur less than 30% of the time on the Chaine Annamatique along the eastern border. Over the Mekong Valley the frequency of $\geq$5,000/5 is slightly over 70%. Excepting some slight improvement over the Chaine Annamatique and the northwestern portion of the country, there is no significant change in frequency or pattern throughout the day.

The frequency of $\geq$1,000/2½ is also at a minimum during the early morning hours and is somewhat less than 50% along the highest elevations of the eastern border regions. Over most of the Mekong Valley and the western border of northern Laos, the frequency exceeds 90%. Considerable improvement in the areas of low frequency generally takes place by mid-afternoon. By 1600 LST all of the country, save the higher elevations of the eastern border regions, has a frequency greater than 90%. (See Fig. 14e, 15e, 16e and 17e.)

TEMPERATURE (°F)

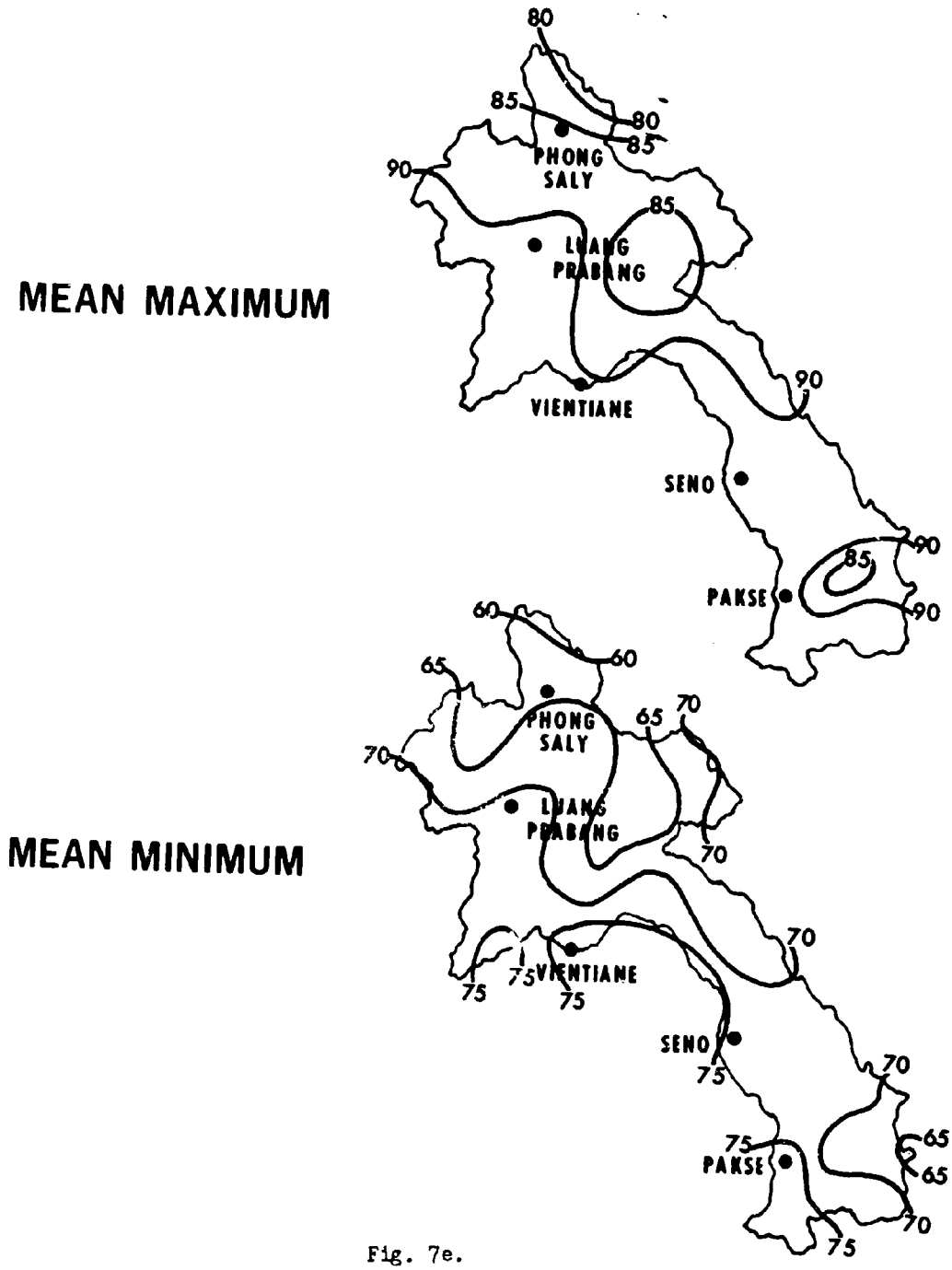


Fig. 7e.

MEAN RELATIVE HUMIDITY (%)

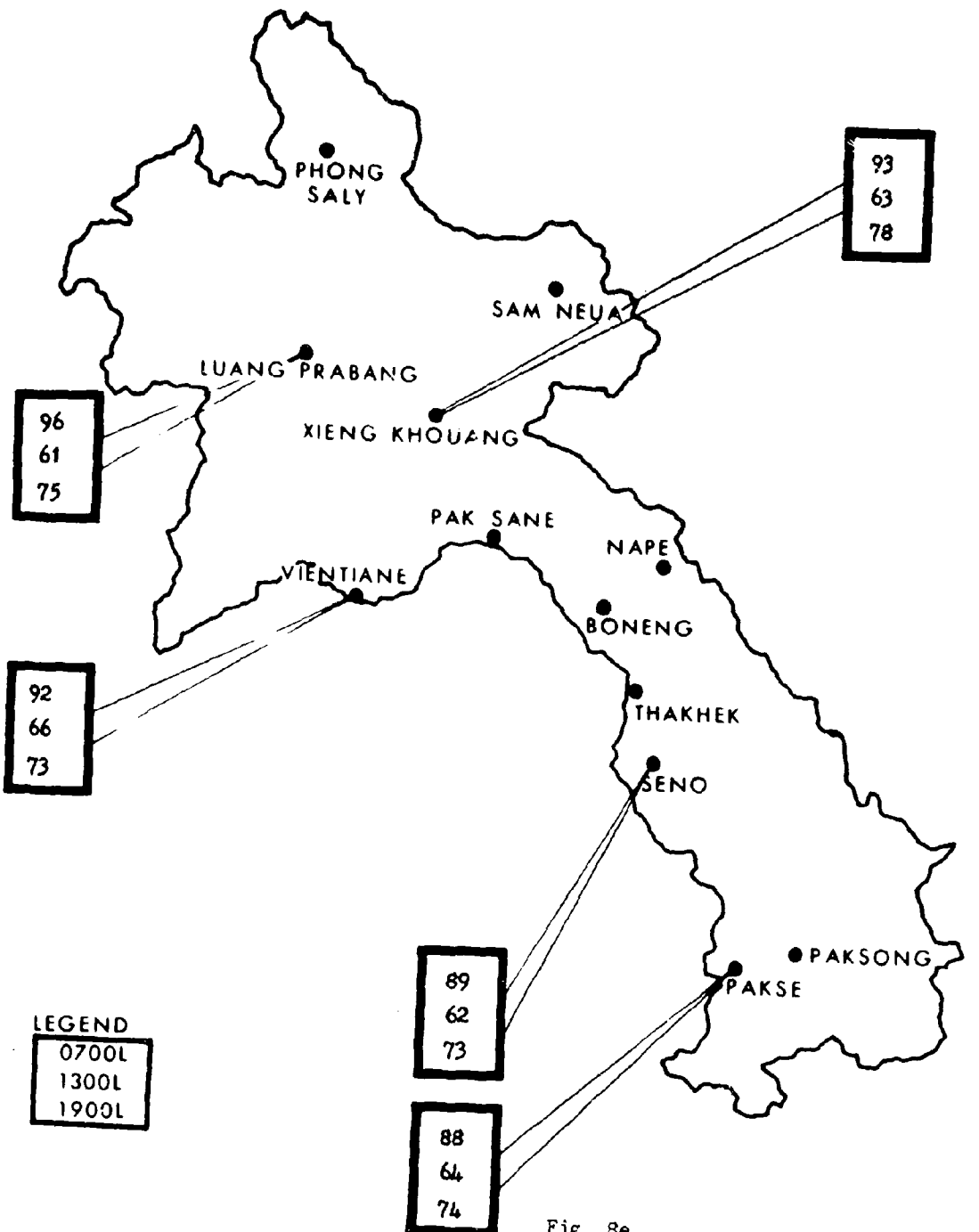


Fig. 8e.

MAY

MEAN NUMBER OF DAYS WITH PRECIPITATION

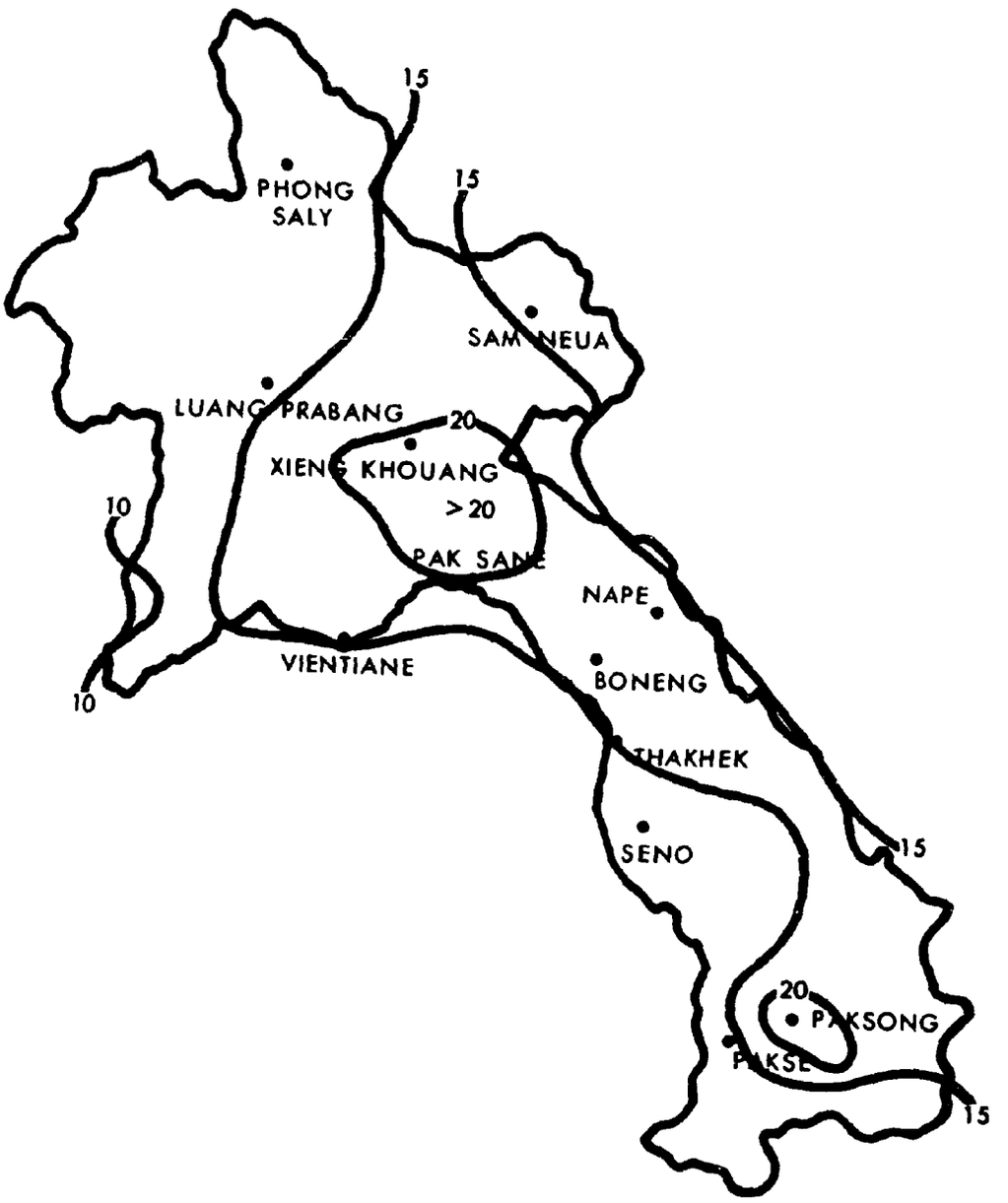


Fig. 9e.

MAY

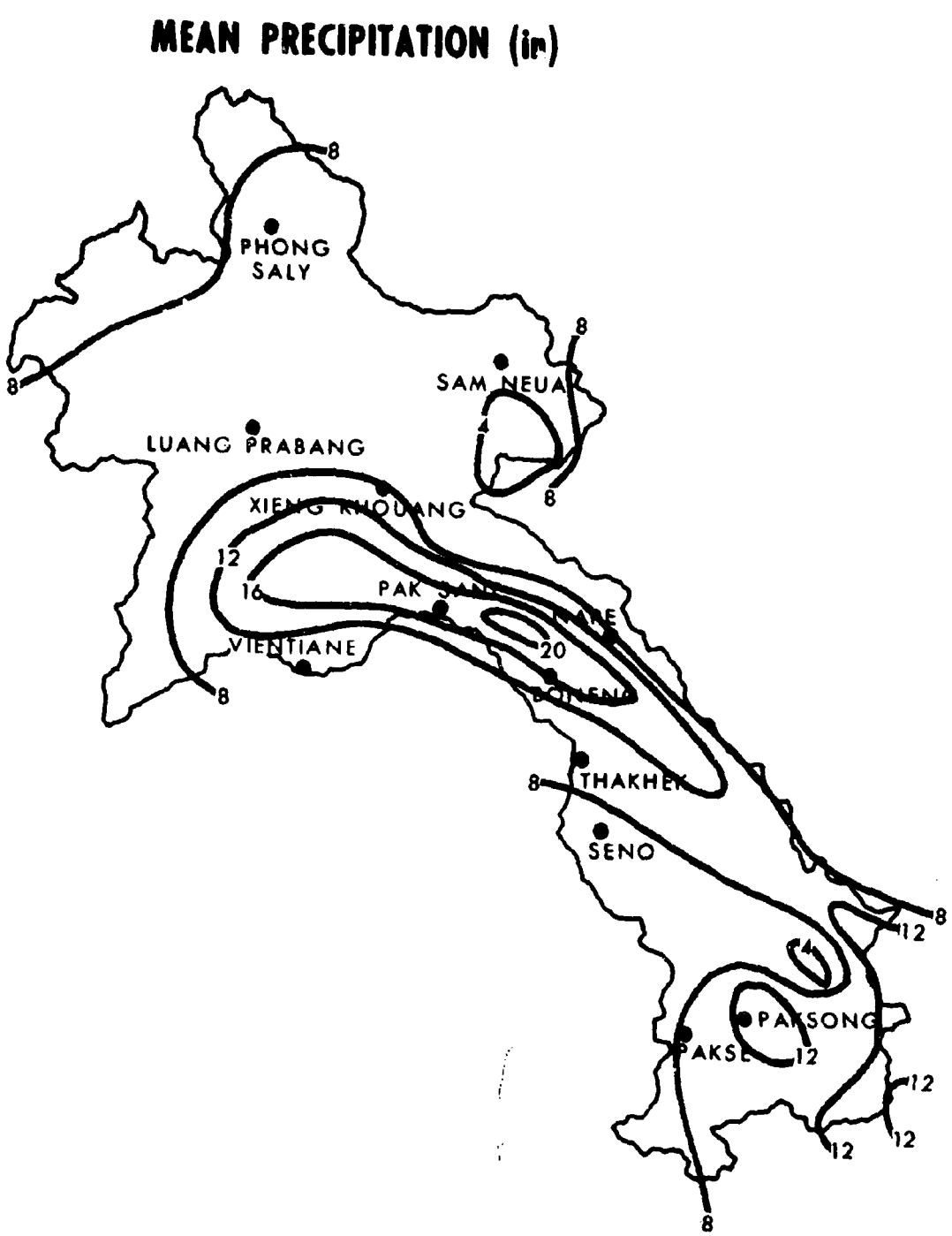

MEAN PRECIPITATION (in)
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
VIENTIANE
THAKHEK
SENO
PAKSONG
PAKSE
8
12
16
20
4
MAY

Fig. 10e

PRECIPITATION and THUNDERSTORMS

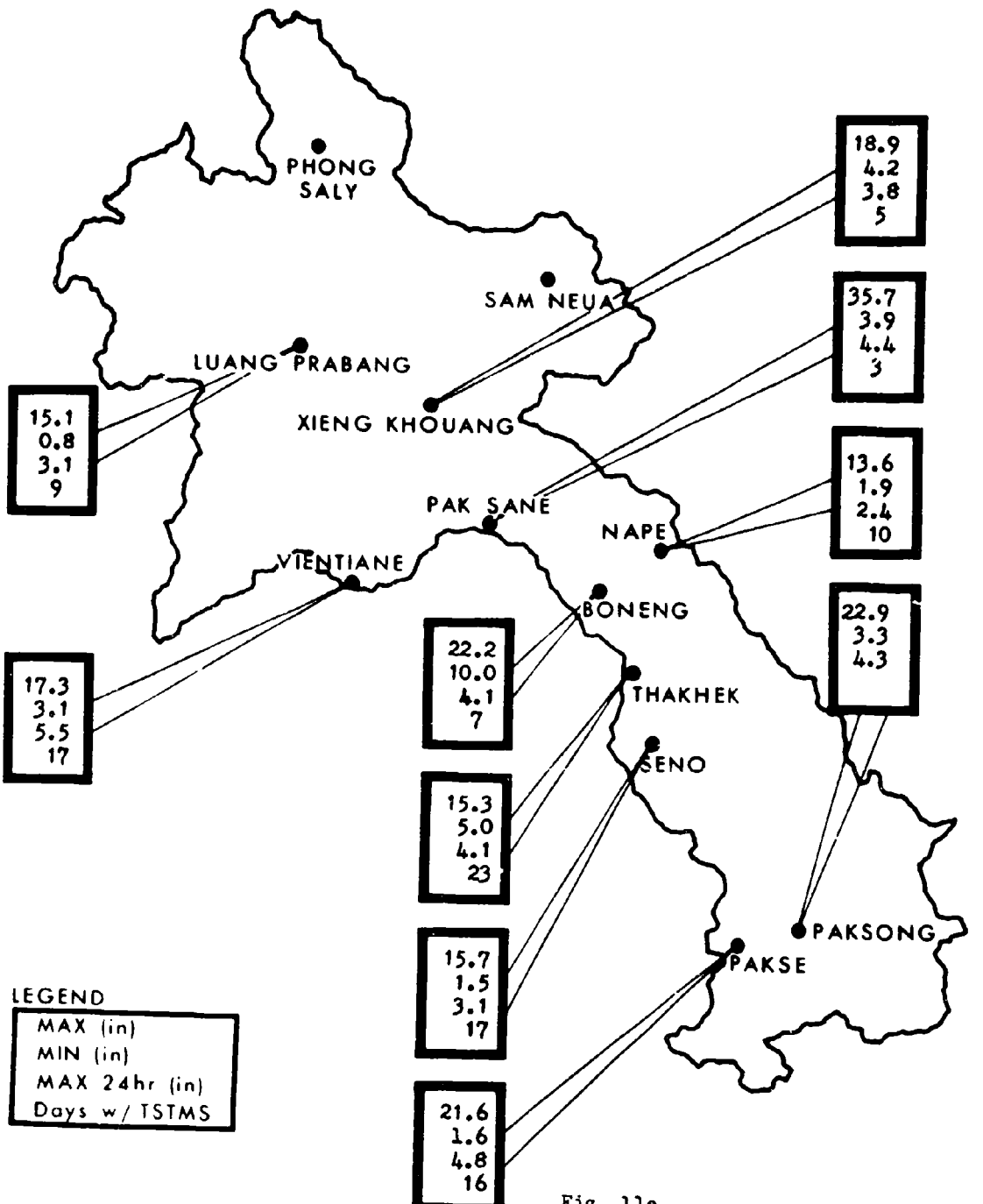


Fig. 11e.

MAY

VISIBILITY

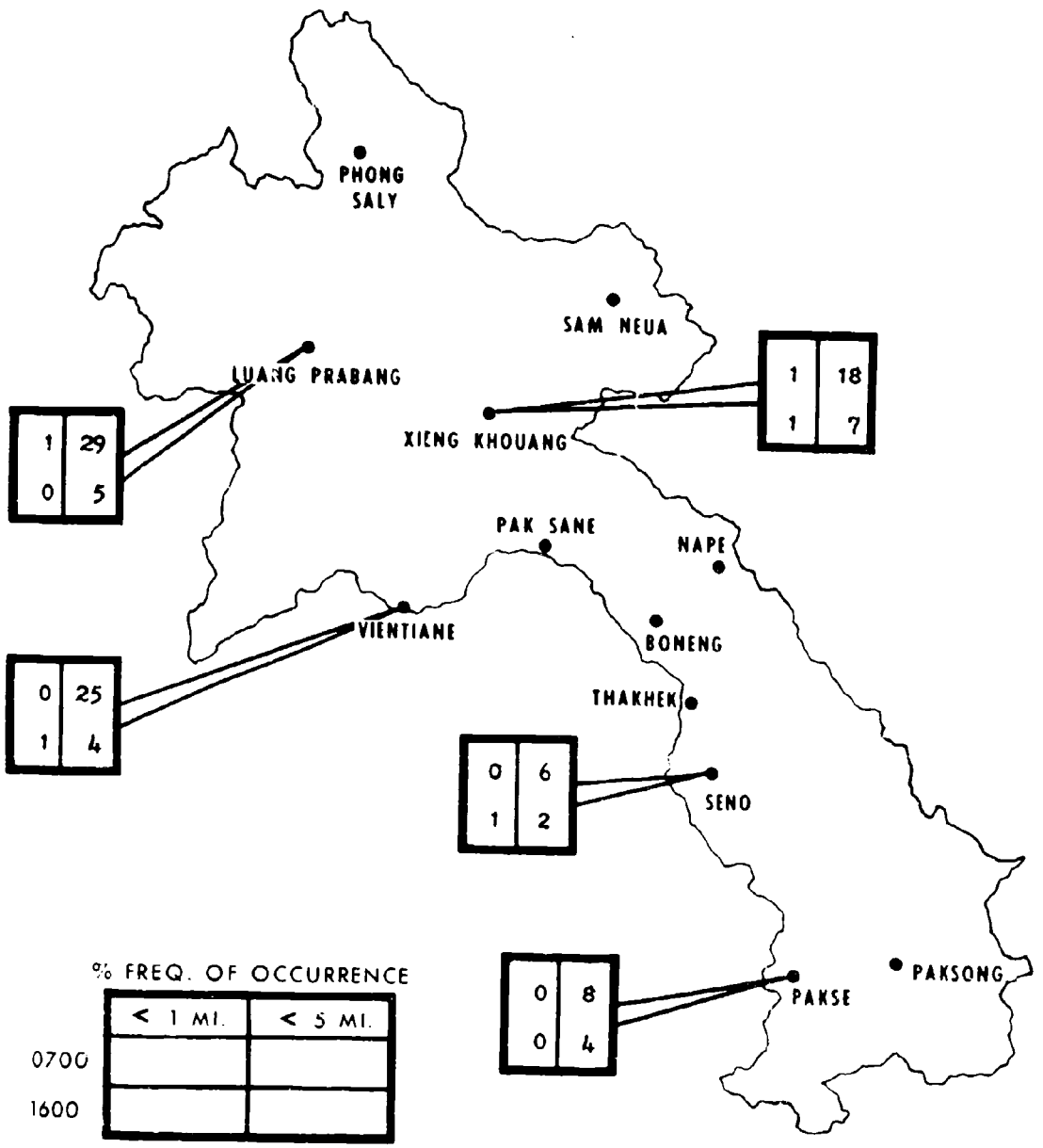


Fig. 12e.

MAY

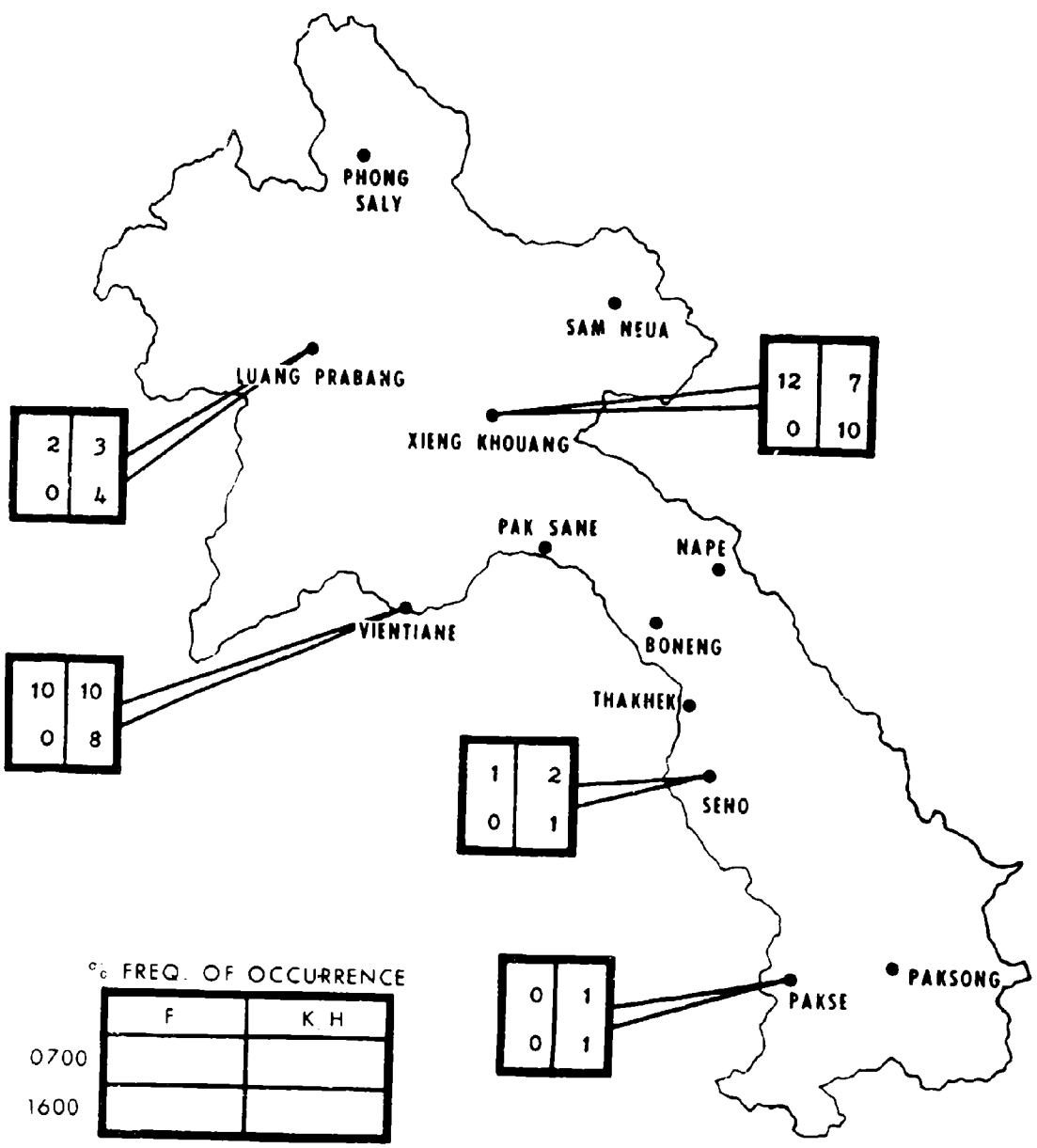

FOG-SMOKE/HAZE
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
PAKSE
2 3
0 4
12 7
0 10
10 10
0 8
1 2
0 1
0 1
0 1
% FREQ. OF OCCURRENCE
F
K H
0700
1600
MAY

Fig. 13e.

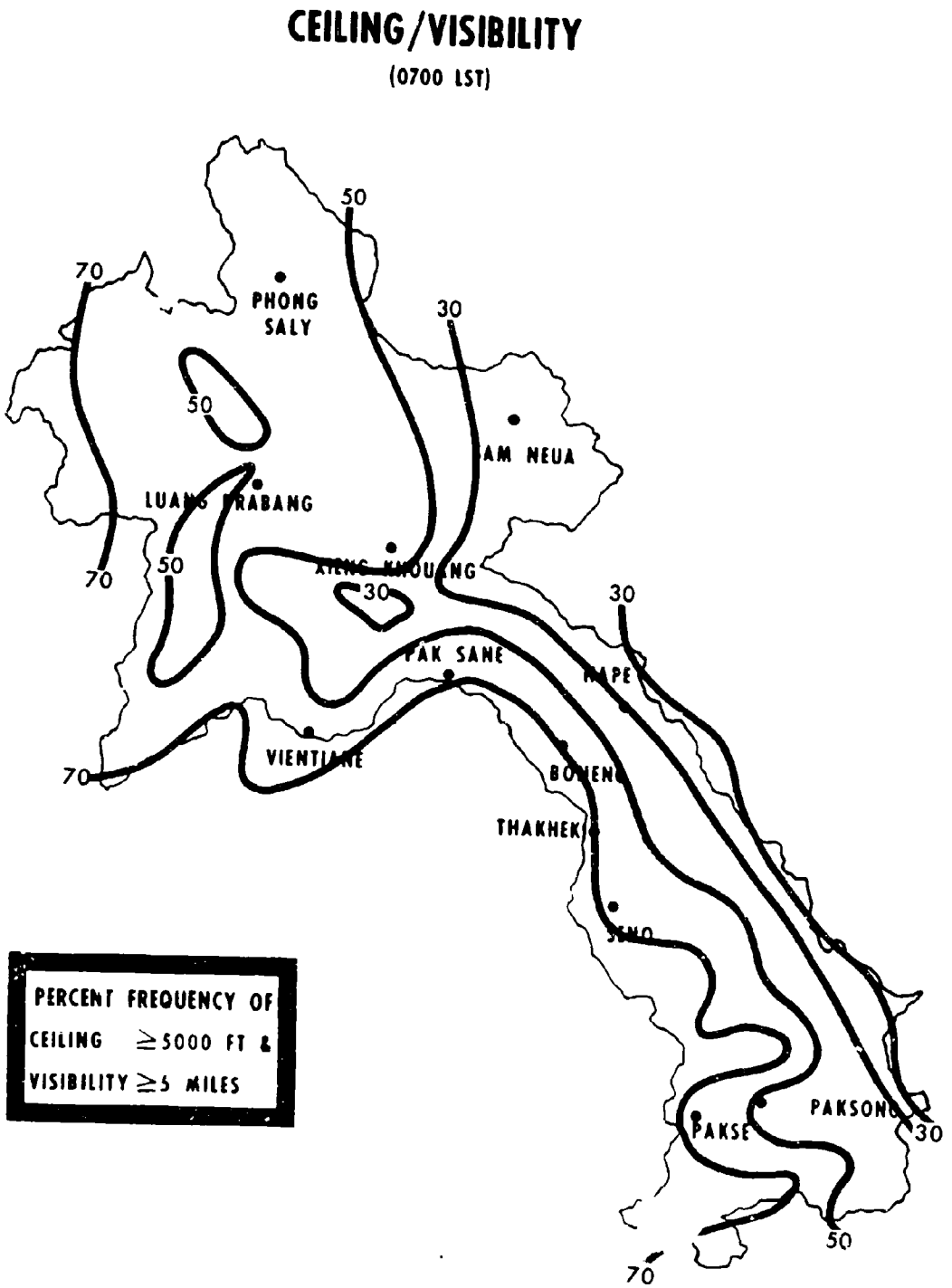

CEILING/VISIBILITY
(0700 LST)
PHONG SALY
LUANG PRABANG
XIENG KHOUANG
AM NEUA
PAK SANE
VIENTIANE
THAKHEK
PAKSE
PAKSONG
50
70
30
PERCENT FREQUENCY OF
CEILING ≧5000 FT &
VISIBILITY ≧5 MILES
MAY

Fig. 14e

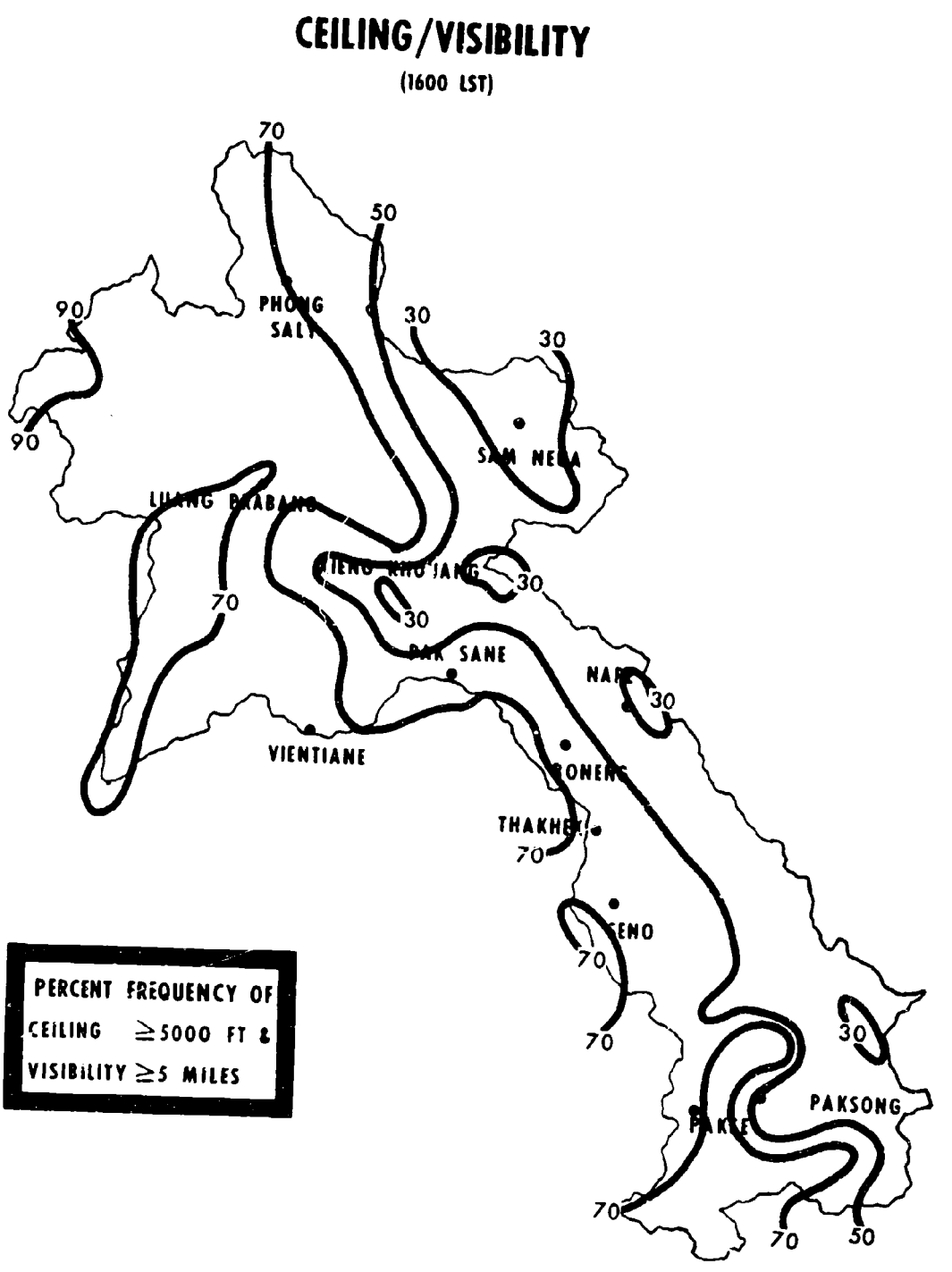

CEILING/VISIBILITY
(1600 LST)
70
50
90
PHONG SALI
30
30
90
SAM NEUA
LUANG PRABANG
70
30
30
PAK SANE
VIENTIANE
70
70
70
70
70
30
PAKSONG
70
70
50
PERCENT FREQUENCY OF
CEILING ≥5000 FT &
VISIBILITY ≥5 MILES
MAY

Fig. 15a

CEILING/VISIBILITY

(0700 LST)

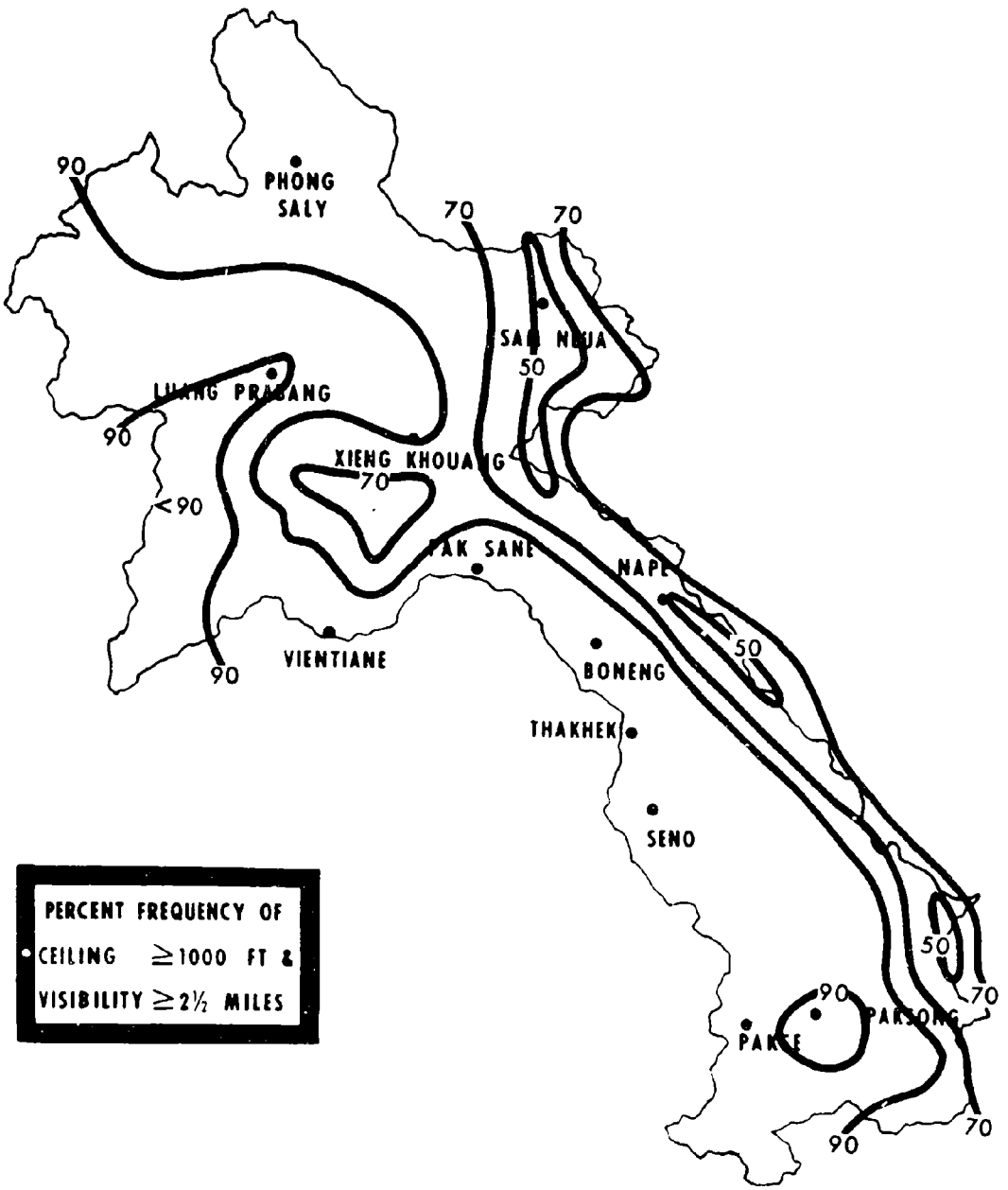


Fig. 16e

MAY

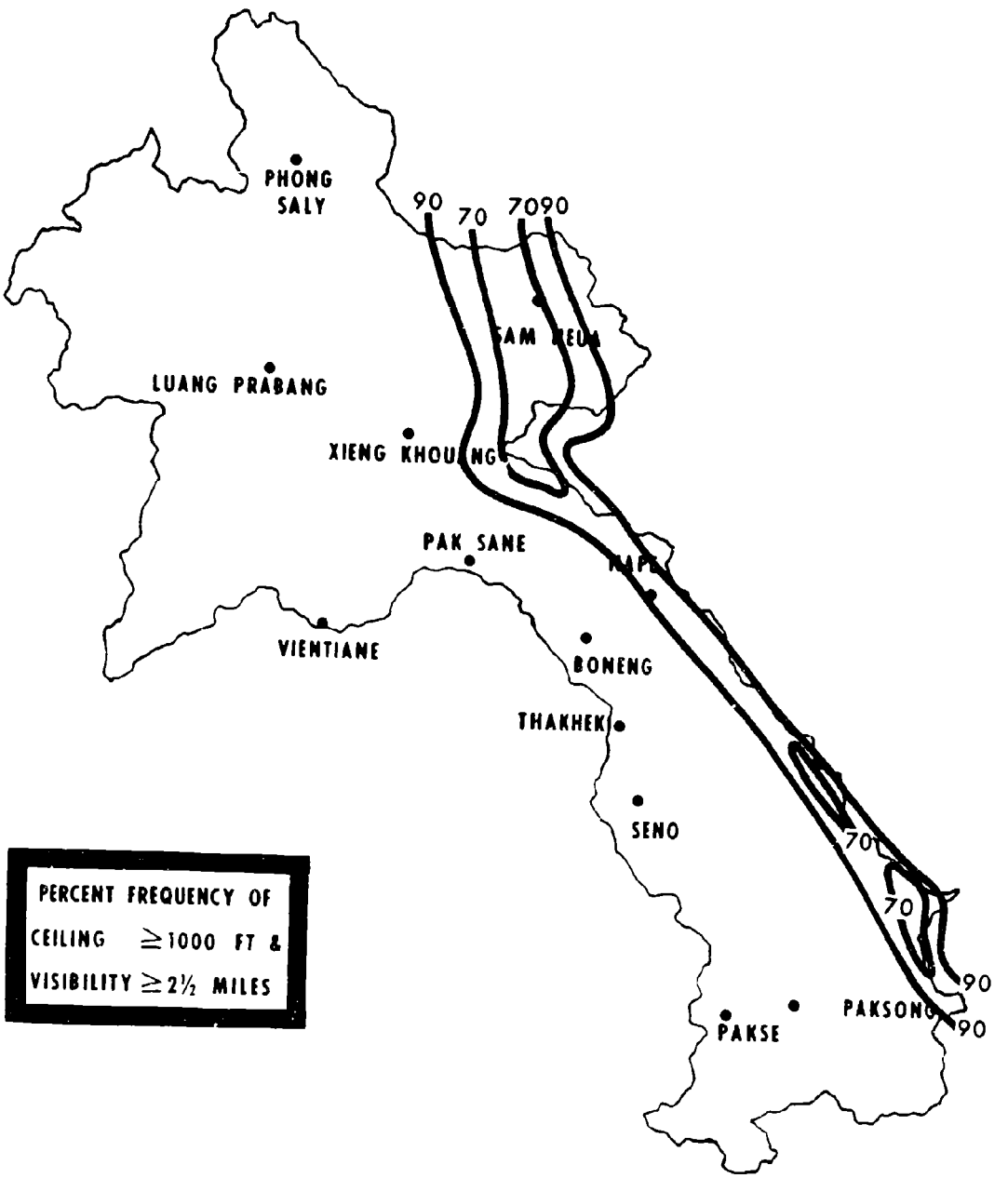

CEILING/VISIBILITY
(1600 LST)
PHONG SALY
LUANG PRABANG
XIENG KHOUANG
PAK SANE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSE
PAKSONG
90
70
70
90
70
70
90
90
PERCENT FREQUENCY OF
CEILING ≥1000 FT &
VISIBILITY ≥2½ MILES
MAY

Fig. 17e

MAY SUNRISE, SUNSET AND TWILIGHT FOR VIENTIANE 17°59'N, 102°34'E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0454	0521	0544	1830	1853	1920	-1.2	1.3
2	0453	0520	0543	1831	1854	1920	-1.2	1.3
3	0453	0520	0542	1831	1854	1921	-1.3	1.3
4	0452	0519	0542	1831	1854	1921	-1.3	1.3
5	0452	0519	0541	1832	1855	1922	-1.3	1.4
6	0451	0518	0541	1832	1855	1922	-1.3	1.4
7	0450	0517	0540	1832	1855	1922	-1.4	1.4
8	0450	0517	0540	1833	1856	1923	-1.4	1.4
9	0449	0516	0539	1833	1856	1923	-1.4	1.5
10	0449	0516	0539	1833	1856	1924	-1.5	1.5
11	0448	0515	0539	1834	1857	1924	-1.5	1.5
12	0448	0515	0538	1834	1857	1925	-1.5	1.5
13	0447	0515	0538	1834	1858	1925	-1.5	1.6
14	0447	0514	0537	1835	1858	1925	-1.6	1.6
15	0446	0514	0537	1835	1858	1926	-1.6	1.6
16	0446	0513	0537	1835	1859	1926	-1.6	1.6
17	0446	0513	0536	1836	1859	1927	-1.6	1.6
18	0445	0513	0536	1836	1900	1927	-1.6	1.6
19	0445	0512	0536	1837	1900	1928	-1.7	1.7
20	0444	0512	0535	1837	1900	1928	-1.7	1.7
21	0444	0512	0535	1837	1901	1929	-1.7	1.7
22	0444	0511	0535	1838	1901	1929	-1.7	1.7
23	0443	0511	0535	1838	1902	1930	-1.8	1.7
24	0443	0511	0535	1838	1902	1930	-1.8	1.8
25	0443	0511	0534	1839	1902	1930	-1.8	1.8
26	0442	0510	0534	1839	1903	1931	-1.8	1.8
27	0442	0510	0534	1840	1903	1931	-1.8	1.8
28	0442	0510	0534	1840	1904	1932	-1.9	1.9
29	0442	0510	0534	1840	1904	1932	-1.9	1.9
30	0442	0510	0534	1841	1905	1933	-1.9	1.9
31	0441	0510	0534	1841	1905	1933	-1.9	1.9

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 18e.

F. JUNE

1. Climatic Brief: During June all of Laos is under the influence of the Southwest monsoon. The weather begins to follow a somewhat regular daily pattern. Afternoon showers occur over parts of Laos almost every day. Cloudiness continues to increase during June and at most locations averages 75 to 85%. Low ceilings occur on a few mornings but are relatively rare during the afternoon and evening except in passing thunderstorms and showers. A normal day will find cumulus clouds forming by mid-morning, lowering and increasing in amount to become broken to overcast by mid-afternoon, then breaking up at night. There is a great deal of middle and high cloudiness over all regions in June.

Visibility is relatively good, but rarely excellent because of the hazy nature of the equatorial air mass. During early morning hours low visibilities occur frequently in haze and smoke near heavily populated areas. Afternoon visibilities, except in precipitation, are good over all the country.

To a major degree, topography determines the distribution of precipitation during June, but in general, rainfall increases in all regions. Locations just upstream of sudden rises in surface relief, as well as locations on exposed mountain slopes and plateaus, average from 18 to 27 in. of precipitation over a period of 20 to 25 days during the month. Amounts of greater than 45 in. for the month and greater than 12 inches in one day have been recorded. Locations to the lee of mountains, in deep sheltered valleys, and some locations in northern Laos averages 4 to 10 inches of rain on 5 to 18 days. Most precipitation occurs in showers and thunderstorms. Thunderstorms are usually intense and of short duration, and they are often accompanied by severe surface winds. At times light rain may persist for several days over an area with occasional heavier showers or thunderstorms superimposed on this pattern.

Temperatures decrease very slightly from their May maximum. Daytime maximums average about 90F at most locations and nighttime minimums drop to the mid-70's. Temperatures above 100F are not common in Laos. Relative humidity average a damp 75 to 85%.

2. Temperatures: Laos, except for higher elevations, has high surface temperatures throughout the year and little local month-to-month variation. June temperatures throughout most of the country are about 3F cooler than those in May. Because of increased cloudiness, diurnal temperature ranges are small during June. No temperature data are available for the region north of 20°N; however, available data from neighboring countries indicate that in this region maximum temperatures average between 75 and 80F. Maximums in this temperature range extend southeastward along the Vietnam border. Elsewhere mean maximums are in the high 80's or low 90's. The highest reported mean maximum is 92F at Luang Prabang. The lowest mean maximum is 76F at Pak Song. The extreme high temperature on record is 104F at Luang Prabang.

Mean daily minimum temperatures generally follow the same pattern as the maximums. Minimums range from 65 to 70F in the northern mountains to 75F along the Thailand border. The highest mean minimum is 76F at Vientiane and Pak Song. The lowest reported mean minimum is 65F at Pak Song and the extreme low temperature on record is 57F at Luang Prabang. (See Fig. 7f.)

3. Relative Humidity: The relative humidity, in general, is high during all seasons in Laos and results in conditions favorable for mildew, corrosion and decay of susceptible items. The high humidity tends to make the high temperature seem even higher.

With the return of the southwest flow in June, relative humidities increase throughout the country. Mean humidities range from 77% at Pakse to 86% at Luang Prabang. The record low humidity is 35% at Pakse. The highest daily humidities occur during the early morning hours and after rainshowers; and the lowest values usually occur during the afternoon. As with temperature, humidity can vary considerably over short distances. The values referred to above are based on reporting stations only. (See Fig 8f.)

4. Precipitation and Thunderstorms: June may be considered a wet season month in Laos. Most of the precipitation that does occur is in the form of afternoon and evening showers or thundershowers. Precipitation amounts increase significantly during the month at most locations. As much as 6 to 8 in. per month increase, in mean amounts, between May and June have been noted. One to 2 days with precipitation in excess of 1 in. can be expected at most locations and a daily rainfall in excess of 2 in. can be expected on at least one day at most locations.

Rainfall occurs on more than 15 days of the month over most of the country except isolated sheltered regions. The rainest part of the country is the central portion, where precipitation amounts average 20 to 25 in. and rainfall can be expected on more than 20 days. The driest region is the area north of 20°N, where although precipitation occurs on 10 to 18 days, amounts are less than 10 in.

The variability in June rainfall is evident by the large variation in the maximum and minimum June precipitation amounts. North of 20°N, minimum monthly values range from less than one in. to 5 in. and maximum values are 15 to 20 in. Over the central region extreme values range from a minimum of 3 in. to a maximum of 25 in. The greatest variation in June amounts at a single location is 31.5 in. at Attopeu, where a minimum value of 3.2 in. and a maximum of 34.7 in. have been observed. Observed maximum one day rainfall amounts are 7 in. or less at all stations; most locations report 24-hr maximums of 4 to 5 in.

In June, thunderstorm activity decreases somewhat over most of the country. Maximum activity is centered along the Mekong River and the windward side of the Annam Range where 12 to 16 thunderstorm days are observed at most locations. The minimum activity is recorded over the

northern half of the country where 5 days or less is the normal. (See Figs 9f, 10f, and 11f.)

5. Cloudiness: With few exceptions, cloudiness continues to increase over Laos in June. Cumulus clouds, with bases 2,000 to 4,000 ft, develop about 1000 LST. Afternoon ceilings continue to increase in frequency over all regions. Mountain tops are frequently obscured as cloud masses build on the windward slopes, and the occurrence of thunderstorm clouds increases everywhere. Broken cloud layers, with bases between 8,000 and 15,000 ft, are associated with afternoon and evening thunderstorms. Nocturnal cloudiness continues to increase during June, and occasionally low cloud ceilings occur. Most of the cloudiness is caused by orographic lifting of the warm, moist air as it approaches the Annam Range. The least cloudiness occurs in the northern mountains, north of Luang Prabang.

Mean cloudiness varies from around 75% north of Luang Prabang to about 85% at Nape. The number of days with total cloud cover equal to or less than 3/10 is 3 days or less throughout the country.

6. Visibility and Obstruction to Vision: With occurrences of fog, haze and smoke decreasing everywhere, visibilities continue to improve during June. Since shower activity inhibits smoke sources and reduces haze, daytime visibilities in June are good. The occurrence of fog decreases throughout Laos during June. Morning visibilities of less than 3 mi occasionally occur in river valley fog, but this fog seldom persists beyond 0900 LST. In mountain valleys north of 20°N and in the Annam Range, fog occurs on 4 to 6 days, but over the rest of the country fog is observed on 2 days or less. Radiation fog is most prevalent and persistent in deep, steep-walled valleys. Fog generally forms during predawn hours and dissipates by 0900 LST, but in deeper valleys it may form earlier and persist through the morning. Haze and smoke in the Vientiane region frequently reduce visibilities to less than 5 mi from shortly after sunset to about noon. Slant range visibility shows little improvement, for as the occurrences of haze and smoke decreases, the frequency of convective cloudiness and showers increases. (See Figs. 12f and 13f.)

7. Wind and Temperatures Aloft: The mean low-level flow is southwesterly over all of Laos and wind speeds are generally light. Local surface wind directions and speeds are influenced by local topography and can deviate significantly from mean winds. Maximum surface winds occur between 1000 and 1800 LST, the period of maximum convective activity. By June the easterly flow in the lower atmosphere has been replaced by southwesterly winds up to about 25,000 ft. Above this southwesterly flow, easterly winds prevail to above 40,000 ft. Upper air temperatures are close to -18C at 25,000 ft throughout the year. During June the mean freezing level over Laos ranges from about 17,500 to 16,000 ft.

8. Combined Ceiling and Visibility: Ceiling and visibilities are poorest during the early morning hours near sunrise with visibilities the

major restrictant. Ceilings of 5000 ft or more accompanied by visibilities of at least 5 mi ($\geq$5000/5) occur less than 30% of the time along major portions of the eastern border. Over parts of the Mekong Valley and western border regions the frequency of $\geq$5000/5 is slightly over 70%. By mid-afternoon some slight improvement in those regions of lowest frequency takes place but elsewhere there is little change. Improvement in visibility is generally offset by an increase in frequency of ceilings below 5000 ft after 1000 LST.

The frequency of $\geq$1000/2 1/2 is also at a minimum during the early morning hours and is somewhat less than 50% along the highest elevations of the eastern border region. Over most of the Mekong Valley and the western border of northern Laos the frequency exceeds 90%. Considerable improvement in the regions of lower frequency generally takes place by mid-afternoon. By 1600 LST frequencies lower than 70% are confined almost exclusively to the ridges of the Chaine Annamatique while much of the rest of the country has a frequency of 90% or more.

TEMPERATURE (°F)

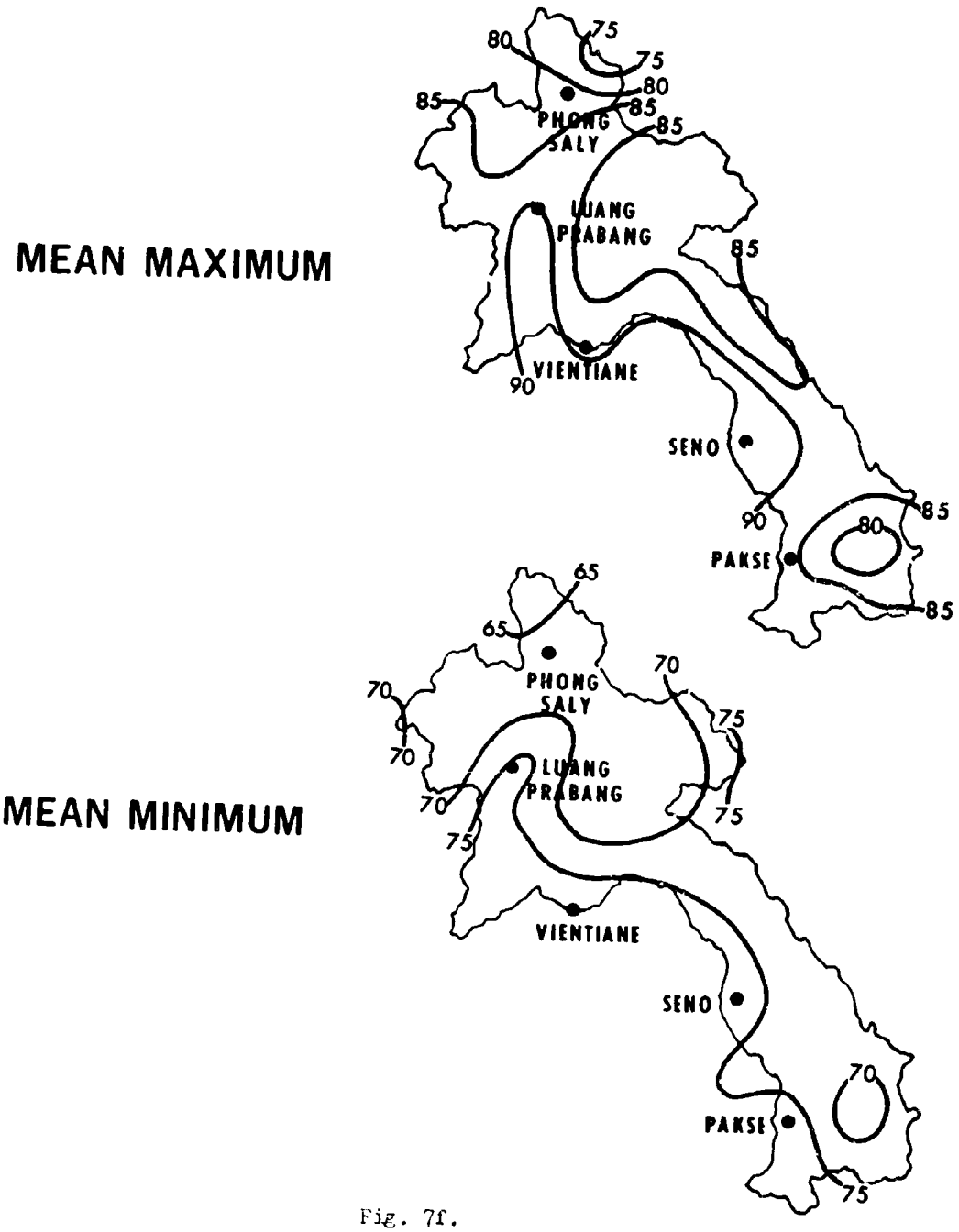


Fig. 7f.

JUN

MEAN RELATIVE HUMIDITY (%)

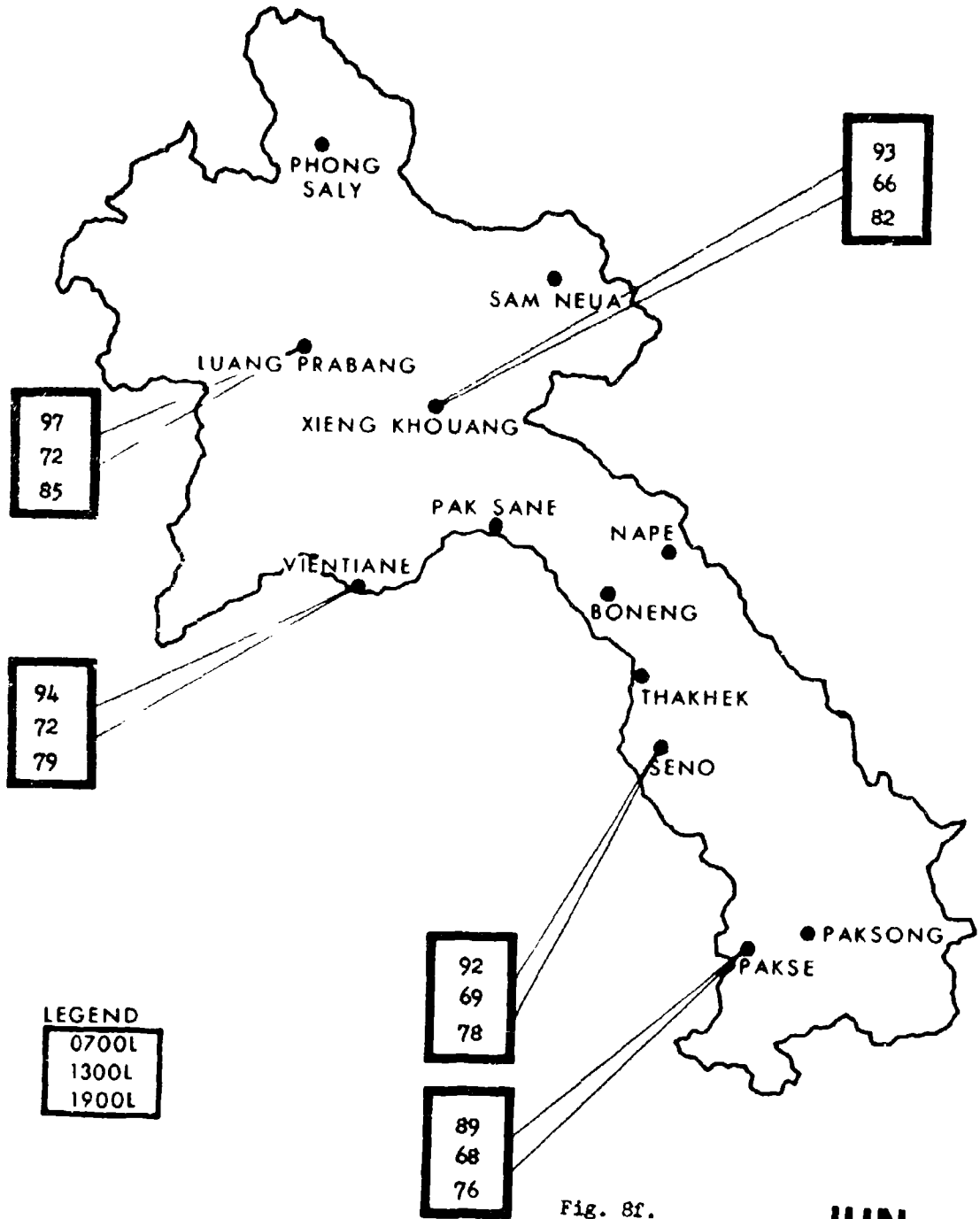


Fig. 8f.

JUN

MEAN NUMBER OF DAYS WITH PRECIPITATION

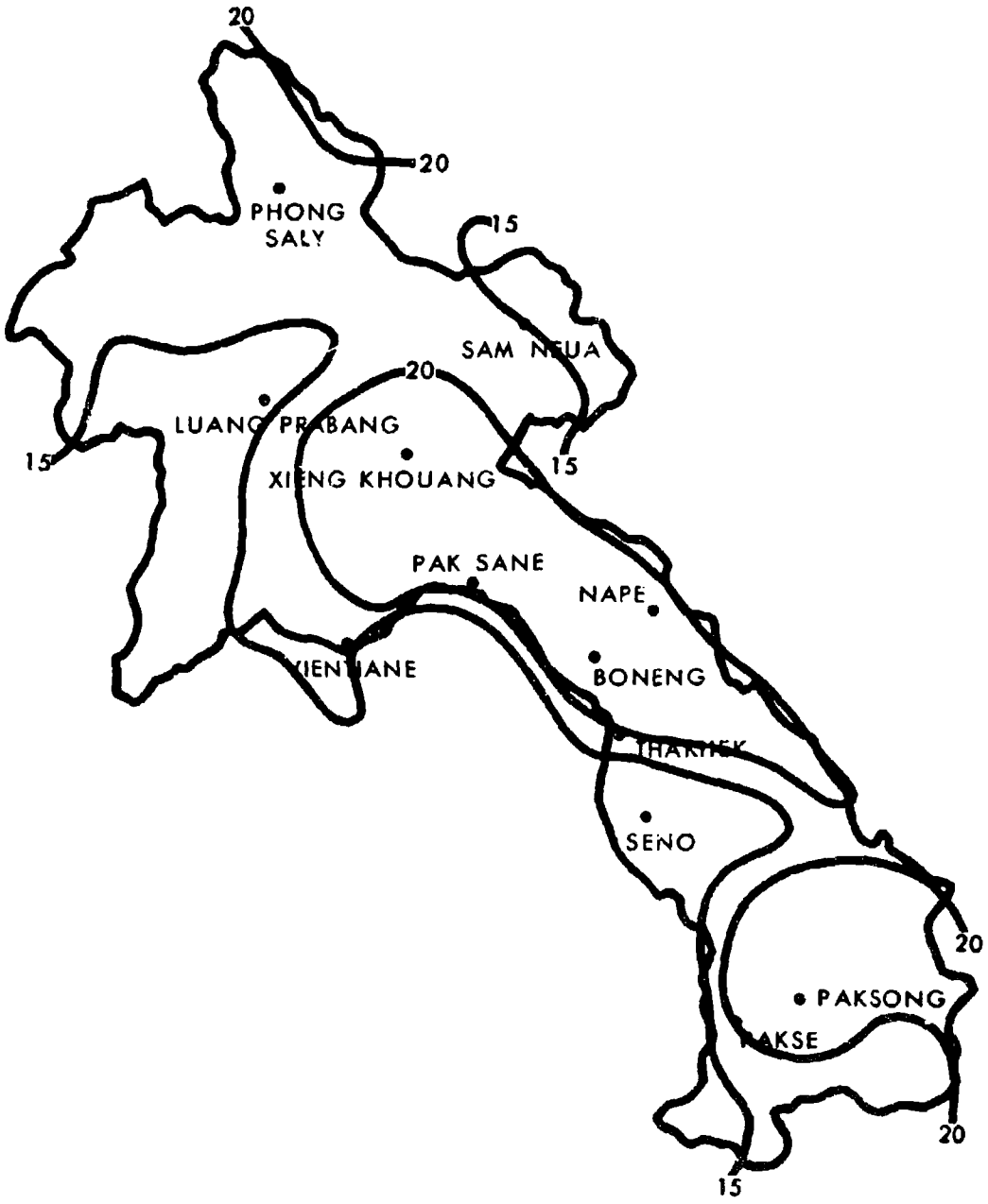


Fig. 9f.

JUN

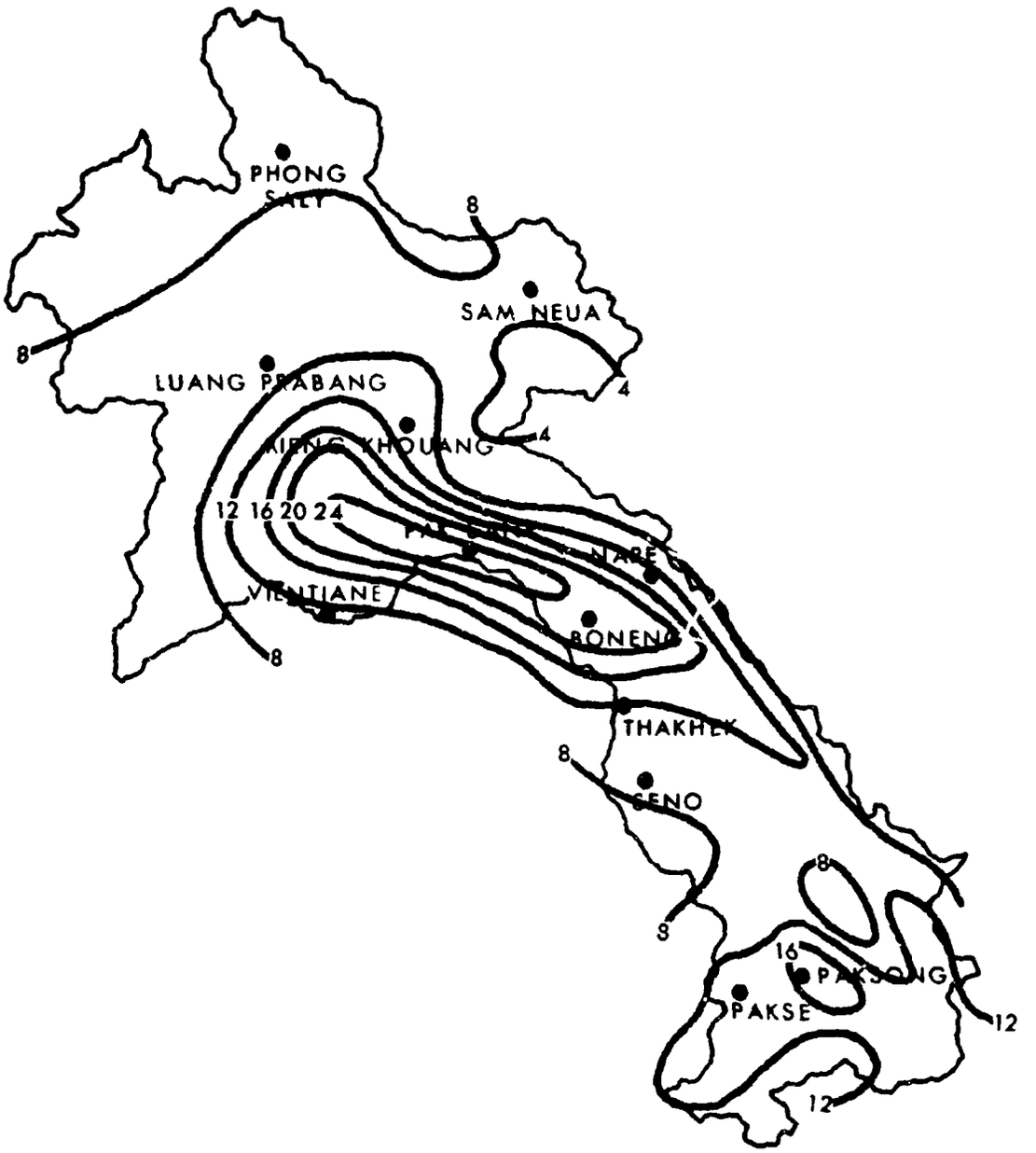

MEAN PRECIPITATION (in)
PHONG SALY
8
SAM NEUA
8
LUANG PRABANG
4
4
12 16 20 24
VIENTIANE
8
NAPE
THAKHEK
8
SENO
8
8
16
PAKSONG
PAKSE
12
12
JUN

Fig. 10f

PRECIPITATION and THUNDERSTORMS

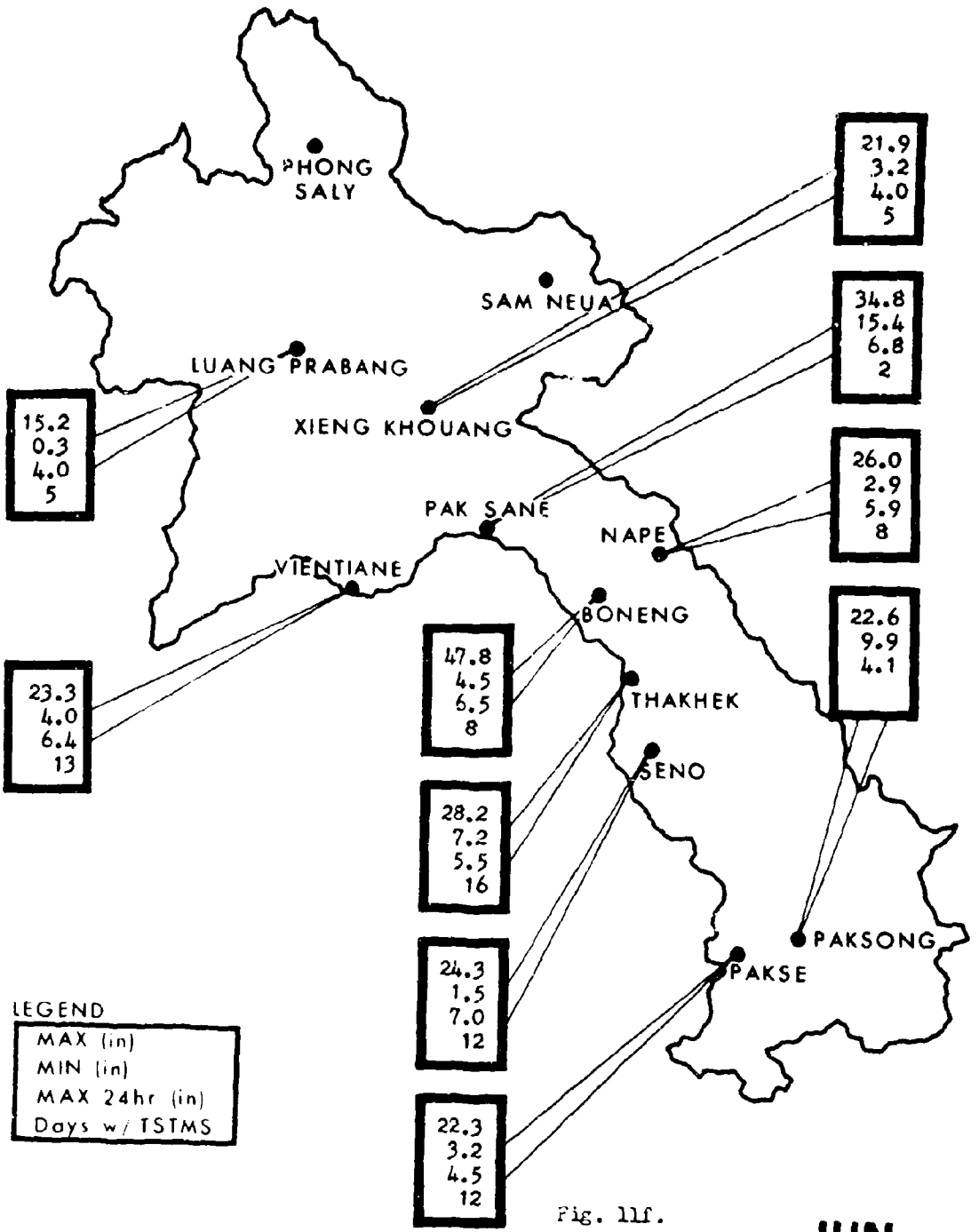
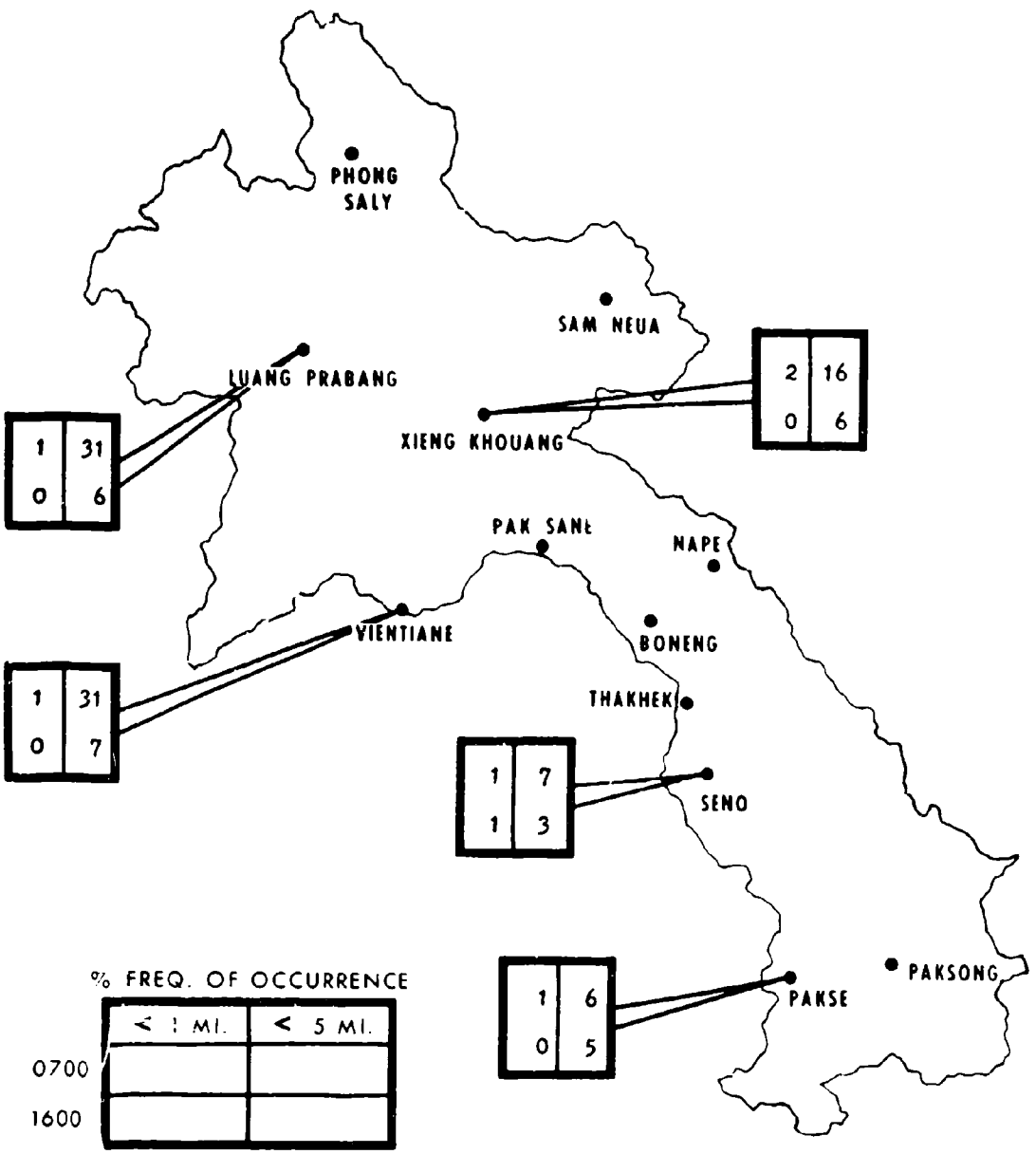


Fig. 11f.

JUN

VISIBILITY



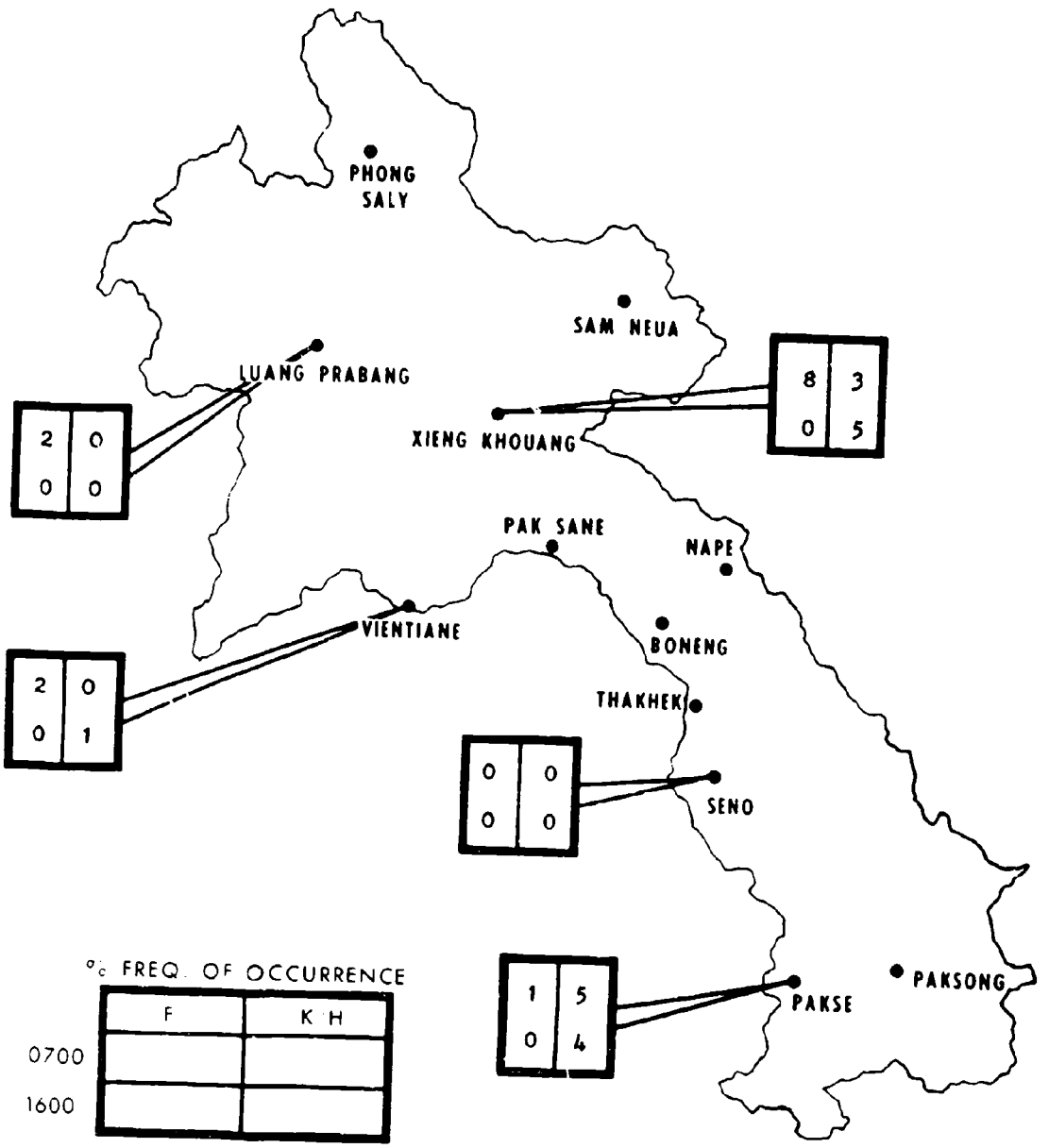
% FREQ. OF OCCURRENCE

	< 1 MI.	< 5 MI.
0700		
1600		

Fig. 12f.

JUN

FOG-SMOKE/HAZE



JUN

Fig. 13f.

CEILING/VISIBILITY

(0700 LST)

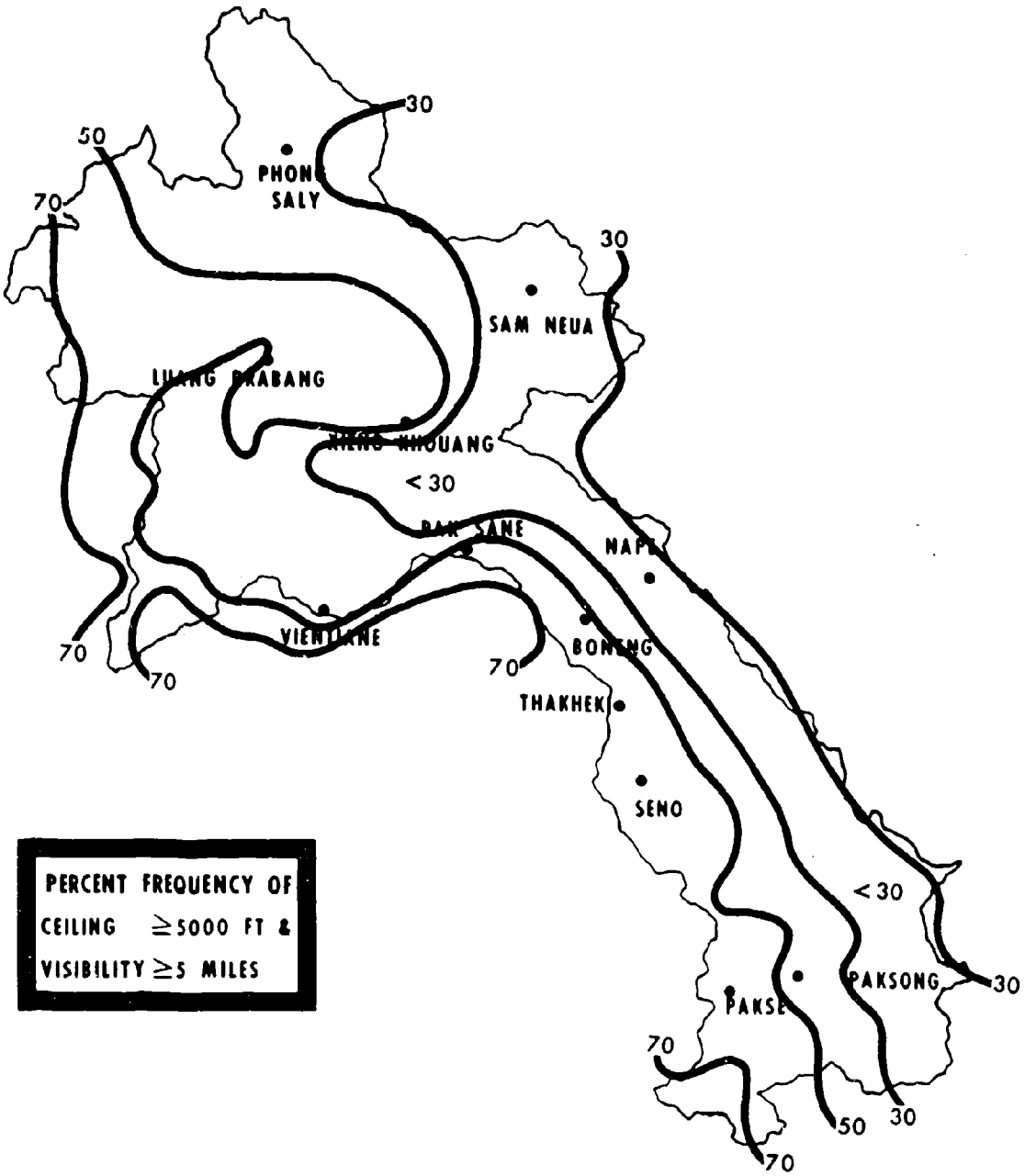


Fig. 1/f

JUN

CEILING/VISIBILITY

(1600 LST)

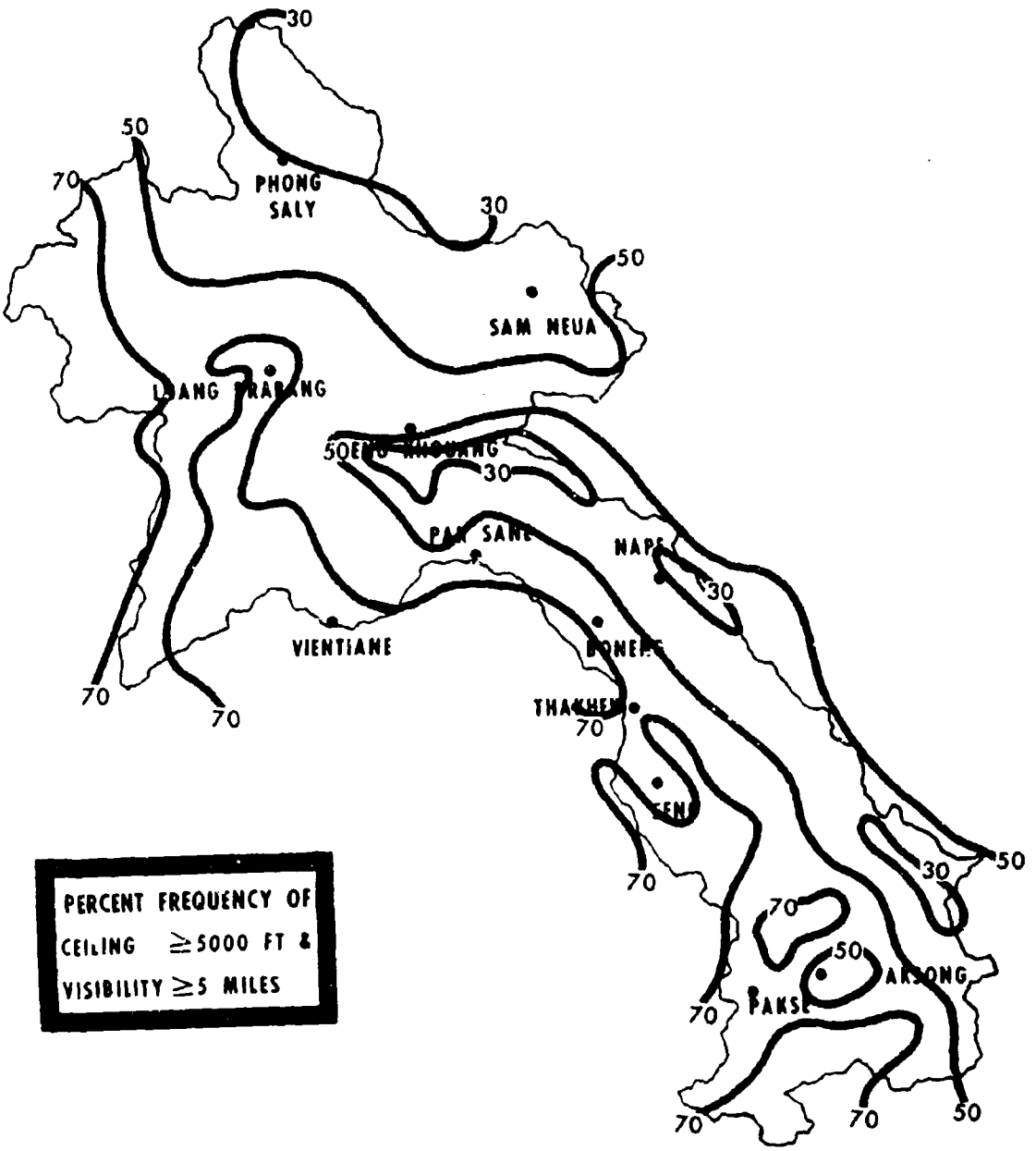


Fig. 15f

JUN

CEILING/VISIBILITY

(0700 LST)

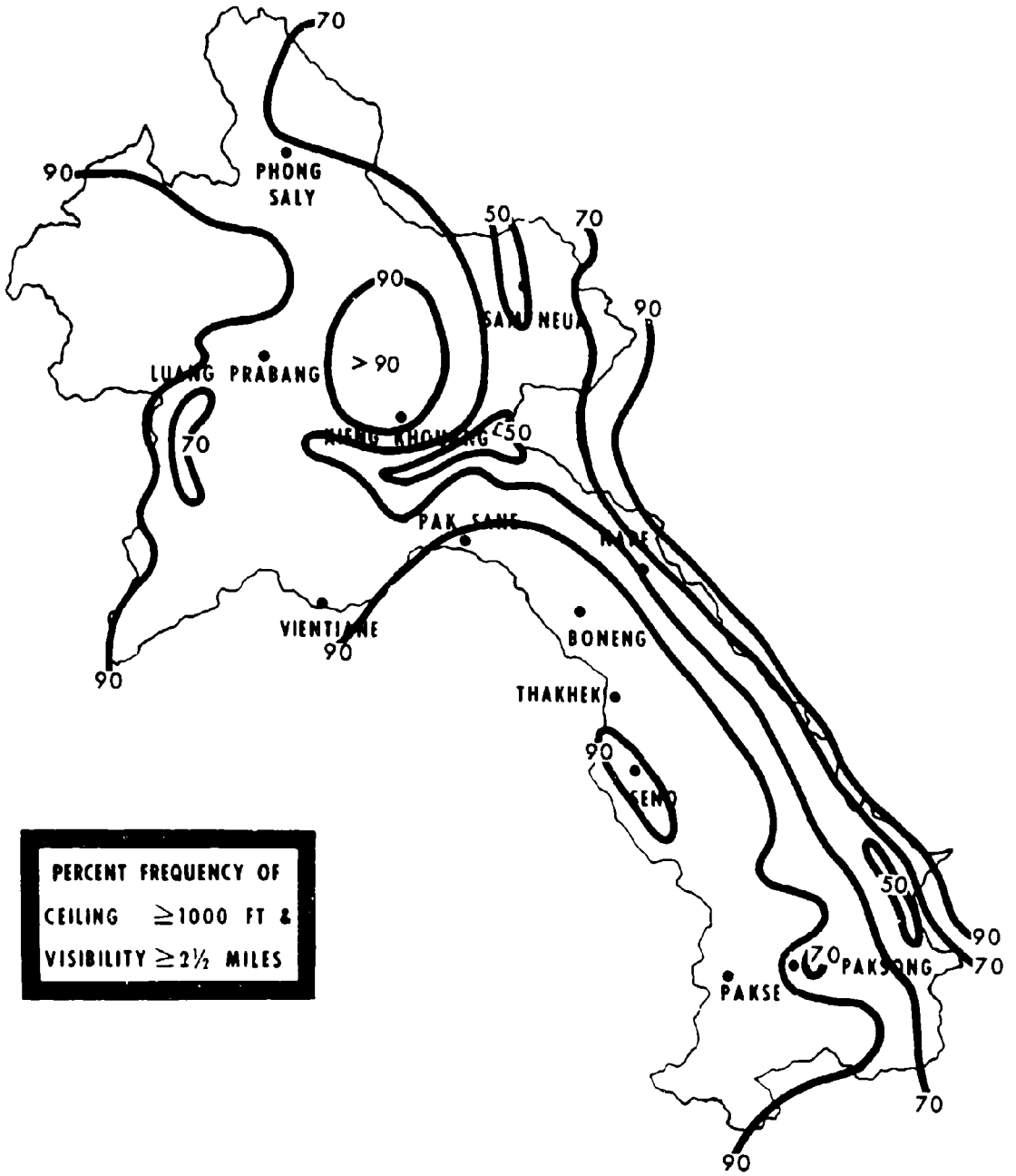


Fig. 16f

JUN

CEILING/VISIBILITY

(1600 LST)

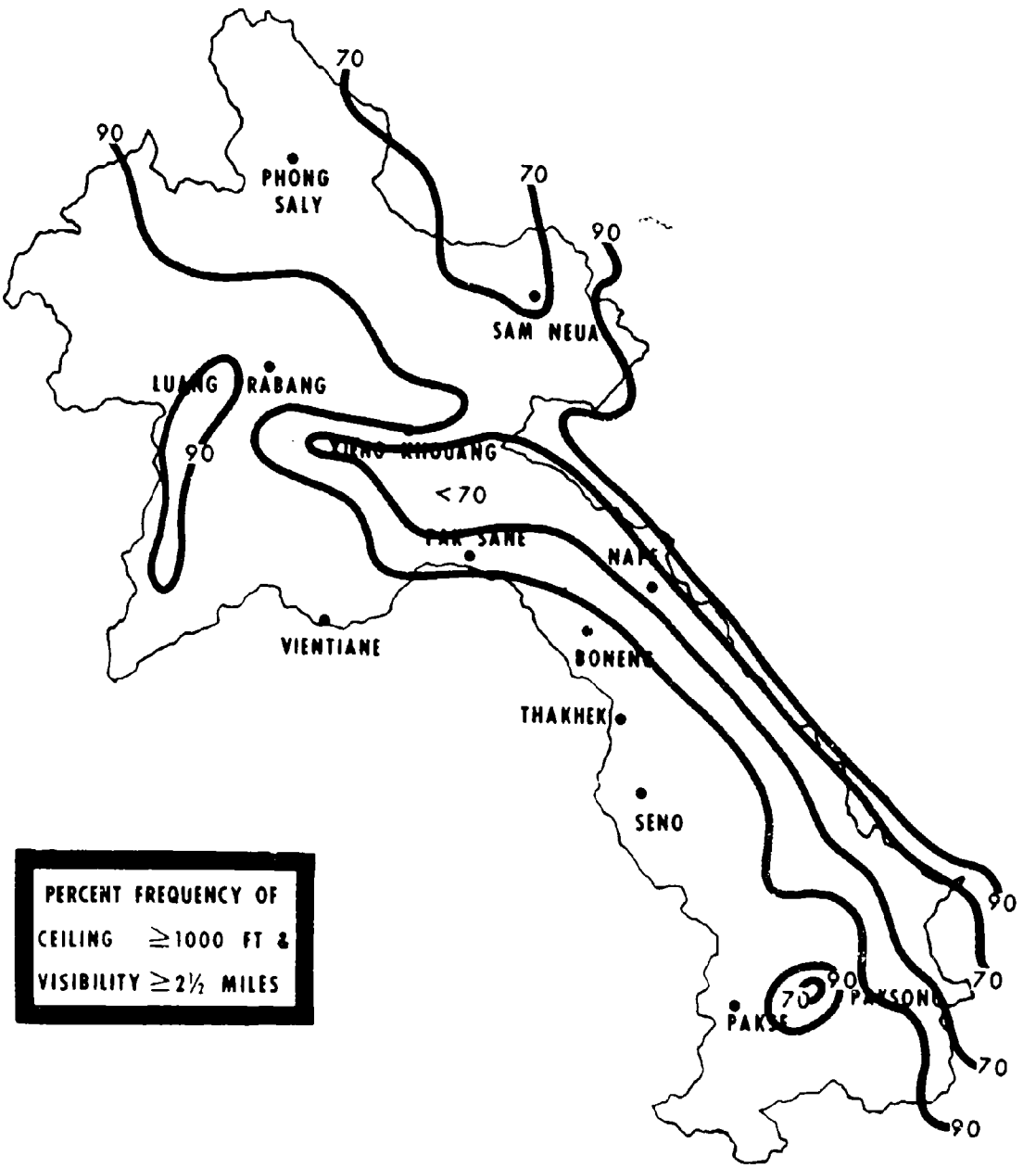


Fig. 17f

JUN

JUNE SUNRISE, SUNSET AND TWILIGHT FOR VIENTIANE (17°59'N, 102°34'E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0441	0510	0533	1841	1905	1934	-1.9	1.9
2	0441	0509	0533	1842	1906	1934	-1.9	1.9
3	0441	0509	0533	1842	1906	1934	-1.9	1.9
4	0441	0509	0533	1842	1906	1935	-1.9	1.9
5	0441	0509	0533	1843	1907	1935	-1.9	1.9
6	0441	0509	0533	1843	1907	1936	-2.0	2.0
7	0441	0509	0533	1844	1908	1936	-2.0	2.0
8	0441	0509	0533	1844	1908	1936	-2.0	2.0
9	0441	0509	0533	1844	1908	1937	-2.0	2.0
10	0441	0509	0533	1845	1909	1937	-2.0	2.0
11	0441	0509	0533	1845	1909	1938	-2.0	2.0
12	0441	0509	0534	1845	1909	1938	-2.0	2.0
13	0441	0510	0534	1845	1910	1938	-2.0	2.0
14	0441	0510	0534	1846	1910	1939	-2.0	2.0
15	0441	0510	0534	1846	1910	1939	-2.0	2.0
16	0441	0510	0534	1846	1910	1939	-2.0	2.0
17	0441	0510	0534	1847	1911	1939	-2.0	2.1
18	0442	0510	0534	1847	1911	1940	-2.0	2.1
19	0442	0510	0535	1847	1911	1940	-2.0	2.1
20	0442	0511	0535	1847	1911	1940	-2.1	2.1
21	0442	0511	0535	1848	1912	1940	-2.1	2.1
22	0442	0511	0535	1848	1912	1941	-2.1	2.0
23	0443	0511	0535	1848	1912	1941	-2.1	2.0
24	0443	0511	0536	1848	1912	1941	-2.1	2.0
25	0443	0512	0536	1848	1913	1941	-2.0	2.0
26	0443	0512	0536	1848	1913	1941	-2.0	2.0
27	0444	0512	0536	1849	1913	1941	-2.0	2.0
28	0444	0513	0537	1849	1913	1942	-2.0	2.0
29	0444	0513	0537	1849	1913	1942	-2.0	2.0
30	0444	0513	0537	1849	1913	1942	-2.0	2.0

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 18f.

G. JULY

1. Climatic Brief: The southwest monsoon is in full force over all of Laos during July. The weather follows a somewhat regular daily pattern with afternoon showers occurring over parts of the area almost every day.

Cloudiness continues to increase during July and at most locations averages 80 to 90%. Overall cloudiness reaches its annual maximum during the latter part of July and August. Low ceilings occur on a few mornings but are relatively rare during the afternoon and evening, except in passing thunderstorms and showers. A normal day will find cumulus clouds forming by mid-morning, lowering and increasing in amount to become broken to overcast, by mid-afternoon, then breaking up at night. There is a great deal of middle and high cloudiness over all regions in July.

Due to the hazy nature of the equatorial air mass, visibilities are usually somewhat reduced. The lowest visibilities generally occur in showers and thunderstorms. During early morning hours moderately low visibilities frequently occur in haze and smoke near heavily populated areas, and with stratus clouds that form on windward mountain slopes.

Topography is a major factor in determining the distribution of precipitation, but in general, rainfall increases in all areas. Locations just upstream of sudden rises in surface relief, as well as locations on exposed mountain slopes and plateaus, average from 22 to 43 in. of precipitation during 24 to 29 days of the month. Amounts of greater than 50 in. for the month and greater than 10 inches in one day have been recorded. Locations in the lee of mountains and deep sheltered valleys average 5 to 9 in. of rain on 10 to 15 days. Most precipitation occurs in showers and thunderstorms. Although thunderstorms do not occur as frequently as during June, they are usually intense and are often accompanied by strong surface winds. Maximum thunderstorms activity is centered in the Mekong River Valley.

Mean temperatures at most locations are one or two degrees cooler in July than in June due to increased cloudiness and precipitation. In the afternoon, temperatures average in the 80's at most locations and fall, at night, to the mid 70's. Temperatures at the higher elevations are somewhat cooler. The humidity continues to increase everywhere and values average a damp 80 to 90%.

2. Temperatures: July temperatures throughout the country are about 1 to 2F cooler than those in June. Because of the heavy cloudiness, diurnal ranges in temperature are small. No data are available for the region north of 20°N; however, available data from neighboring countries indicate that maximum temperatures in this region average between 75 and 80F. Maximums in this temperature range extend southeastward along the Vietnam border, and also occur in the southern panhandle. Elsewhere, mean maximums are in the high 80's or low 90's. The highest reported mean maximum is 90F at Luang Prabang; the lowest is 73F at Pak Song. The extreme high temperature on record is 103F at Luang Prabang.

Mean daily minimum temperatures usually follow the same areal pattern as the maximums. Minimums range from 65 to 70F in the northern mountains to 75F along the Thailand border. The highest mean minimum is 75F at several locations. The lowest reported mean minimum is 65F at Pak Song. The extreme low temperature of 57F has also been recorded at Pak Song. (See Fig. 7g.)

3. Relative Humidity: Relative humidity is high throughout Laos resulting in conditions favorable for mildew, corrosion, and decay of susceptible items. The high humidity tends to make the high temperature seem even higher. Mean humidity values over most of Laos are between 80 and 90%. The highest mean humidity is 87% at Luang Prabang and the lowest is 80% at Seno. The recorded low humidity is 38% at Luang Prabang. The highest daily humidities occur during the early morning hours and after rainshowers, and the lowest values usually occur during the afternoon. (See Fig. 8g.)

4. Precipitation and Thunderstorms: Precipitation amounts increase significantly from June to July, with the largest increase about 28 in., occurring on windward mountain slopes north of the Boloven's Plateau. Rainfall is generally light over northern regions and leeward slopes, but over windward slopes and exposed locations in central and southern Laos, moderate to heavy rainfall frequently occurs. At most stations a daily rainfall in excess of 1 in. occurs on 2 or more days.

Rainfall occurs on more than 15 days of the month over all regions. The rainest part of the country is on and east of the Plaine of Jarres in central Laos, and north of the Boloven's Plateau in the south. In these areas mean values are 29 to 36 in. and 40 to 44 in., respectively, with precipitation occurring on more than 25 days. The driest area occurs in the Mekong River valley in the northwest, where although rain falls on 13 or more days, mean amounts are under 11 in.

The variability in July rainfall is evident by the large variation in maximum and minimum July precipitation amounts. In the north minimum values range from 2 to 8 in. and maximums are 19 and 26 in. Over central Laos minimums are 6 to 12 in. and maximums are 30 to 50 in. The greatest variation occurs over windward slopes in the southern panhandle, where minimum monthly amounts are 22 in. and maximums are 90 in. Observed maximum one day rainfall values range from 3 in. at Sam Neua to 12 in. at Takhek, but most stations report 24-hr maximums of 5 to 8 in.

From June to July there is a slight decrease in thunderstorm activity. They normally occur during the late afternoon and usually last only a few hours. During July, thunderstorms are caused by a combination of afternoon convection and orographic lifting. They are seldom violent; nevertheless, strong surface winds can occur. Maximum thunderstorm activity, 10 to 15 thunderstorm days, occurs in the northwestern mountains and along the southwest border. Minimum activity, less than 5 local thunderstorm days, occurs over the Plaine of Jarres. (See Figs. 9g, 10g and 11g.)

5. Cloudiness: Cloudiness over Laos is increasing through July as it approaches an August maximum. Most cloudiness is caused by orographic lifting of warm, moist air as it approaches the Annam Range. Convective clouds form during the late morning hours and 2000 to 3000 ft ceilings are frequent during the afternoon. Mountain tops are frequently obscured as cloud masses build on windward slopes. Broken cloud layers with bases between 8,000 and 15,000 ft are associated with afternoon and evening thunderstorms. Cirrus clouds, above 30,000 ft, are common. In general, mean cloudiness over the country ranges from 80 to 90%. The mean number of days with total cloud cover equal to or less than 3/10 is 1 to 3 days throughout the country.

6. Visibility and Obstruction to Vision: With shower activity inhibiting smoke sources and reducing haze, daytime visibilities in July are good. Showers and thunderstorms reduce visibilities to less than 5 mi for brief periods, and in more intense storms, to less than 1 mi. Morning visibilities of less than 3 mi occasionally occur in river valley fog, but these conditions seldom persist beyond 0900 LST. In mountain valleys north of 20°N and in the Annam Range, fog occurs on 4 to 6 days, but over the rest of Laos fog is observed on 2 days or less. Radiation fog is most likely in river valleys, and most prevalent and persistent in deep, steep-walled valleys. Haze and smoke in northern Laos frequently reduces visibility to less than 5 mi from shortly after sunset to about noon. Slant range visibility shows little improvement, for as the occurrence of haze and smoke decreases, the frequency of convective cloudiness and showers increases. Visibilities greater than 12 mi are not common anywhere over Laos. (See Figs. 12g and 13g.)

7. Wind and Temperatures Aloft: Mean low-level winds continue to be southwesterly over all of Laos, but there is an increase in speeds from those of June. Local surface winds, both directions and speeds, are influenced by local topography and can deviate significantly from mean winds. Most cases of strong gusty surface winds are associated with thunderstorm activity, but high winds can be caused by channeling (Venturi effect). Channeling can be expected in mountain regions where valleys or passes face the prevailing wind. The winds are compressed and the speeds increased as they flow through the narrow confines.

There is insufficient data on which to base firm estimates of extreme surface winds over Laos but over neighboring South Vietnam wind gusts greater than 60 kt have been reported in both the highlands and lowlands and maximum thunderstorm winds of 70 kt have been reported in upper Thailand.

Southwesterly to westerly winds extend to a little above 20,000 ft over all of Laos. Above this level, easterly and northeasterly winds prevail to above 40,000 ft. Upper air temperatures are close to -18C at 25,000 ft throughout the year. During July the mean freezing level ranges from about 17,500 ft in the north to near 15,500 ft in the south.

8. Combined Ceiling and Visibility: Combined ceilings and visibilities are poorest during the early morning hours near sunrise with visibilities being the major restrictant. Ceilings of 5000 ft or more accompanied by visibilities of at least 5 mi ($\geq$5000/5) occur less than 10% of the time over the higher elevations along the eastern border regions. Over some of the Mekong Valley and western border the frequency of $\geq$5000/5 is as great as 70%. By mid-afternoon some slight improvement in those regions of lowest frequency takes place but elsewhere there is little change. Any improvement in visibility between morning and afternoon is generally offset by an increase in frequency of ceilings below 5000 ft after 1000 LST.

The frequency of $\geq$1000/2 1/2 is also at a minimum during the early morning hours and is somewhat less than 50% along the highest elevations of the eastern border regions. Over most of the Mekong Valley and western border of northern Laos the frequency is at or near 90%. Some improvement in the regions of lower frequency generally takes place by mid-afternoon. By 1600 LST frequencies lower than 70% are confined almost exclusively to the ridges of the Chaine Annamatique while much of the rest of the country has a frequency of 90% or more.

TEMPERATURE (°F)

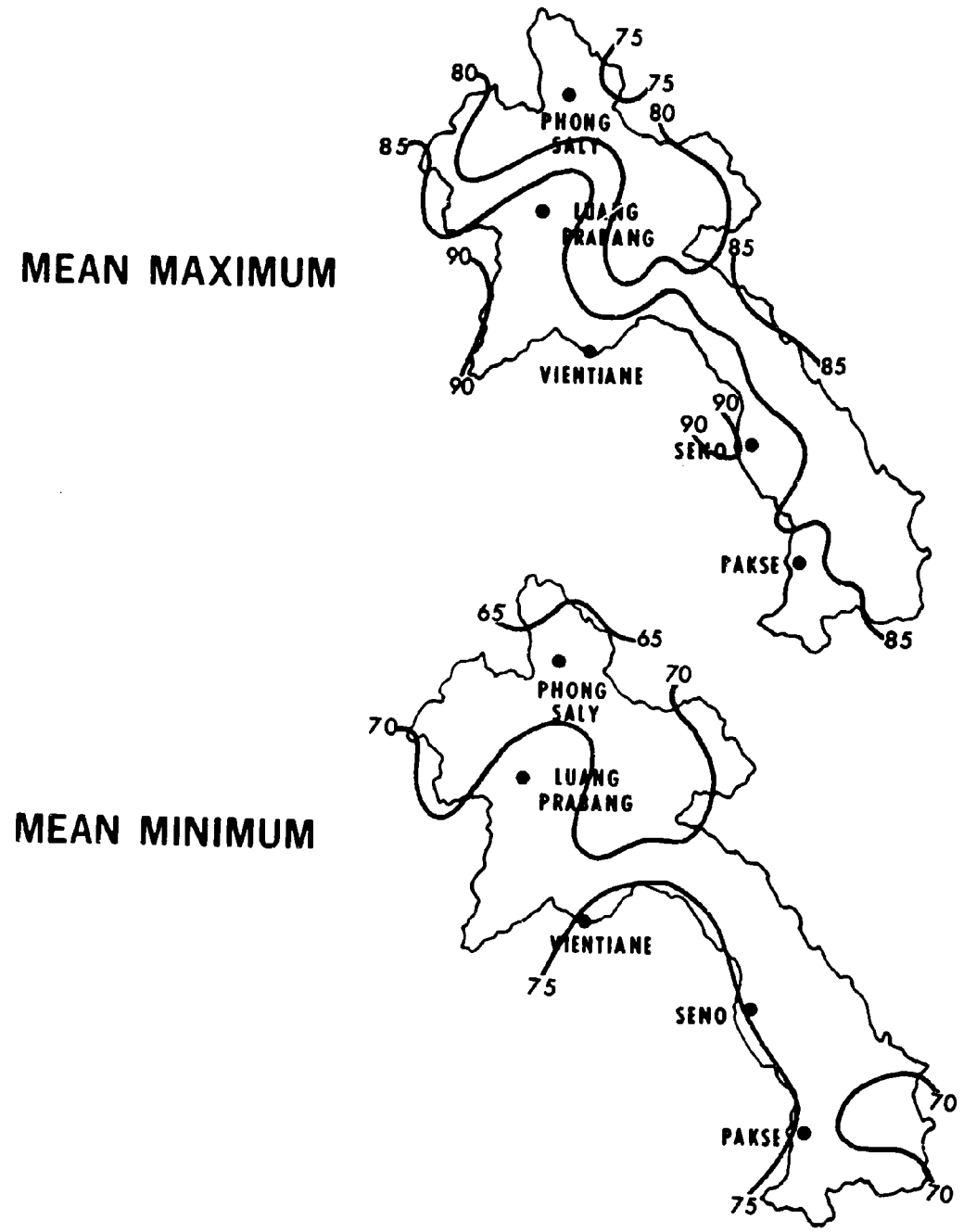


Fig. 7g.

JUL

MEAN RELATIVE HUMIDITY (%)

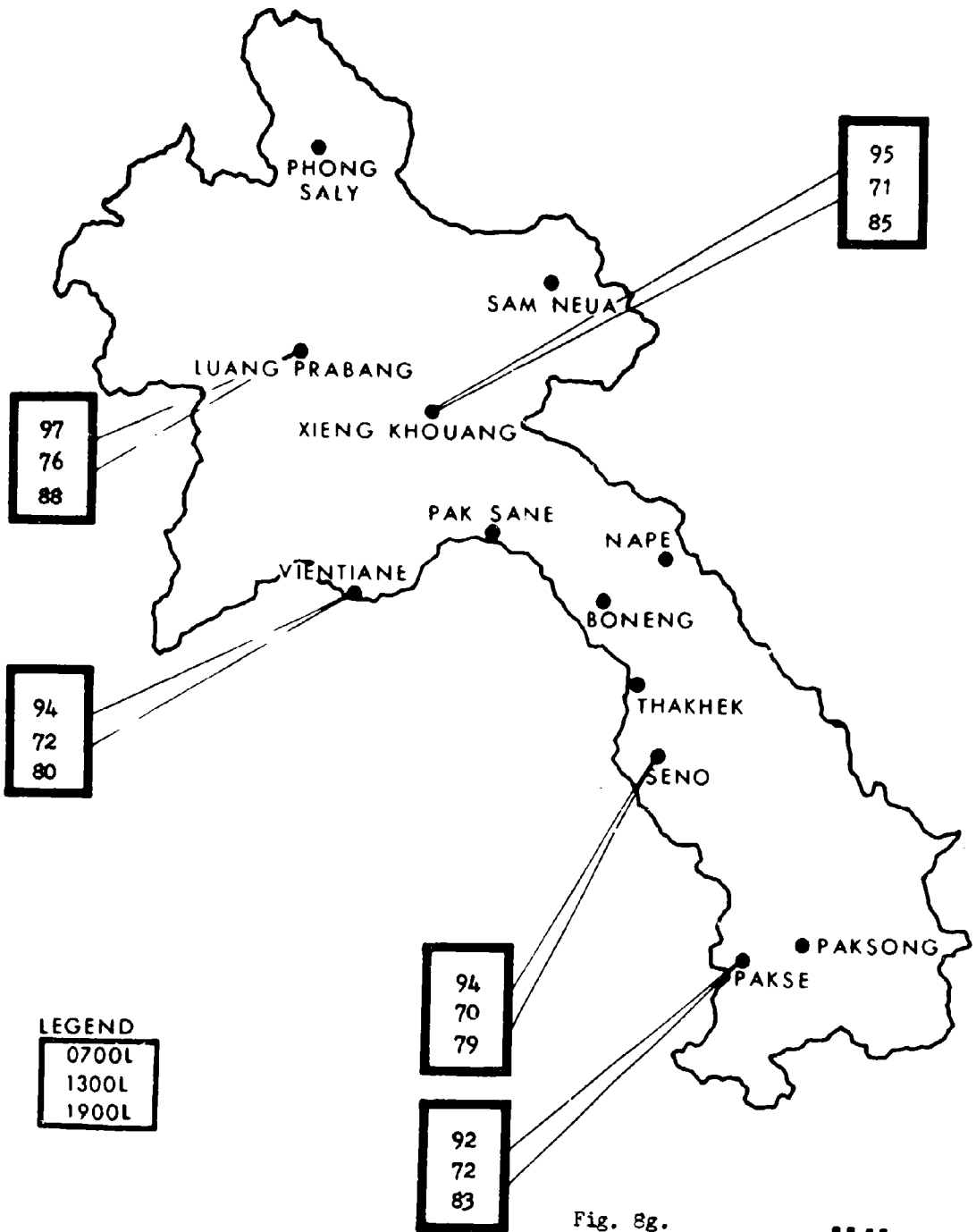


Fig. 8g.

JUL

MEAN NUMBER OF DAYS WITH PRECIPITATION

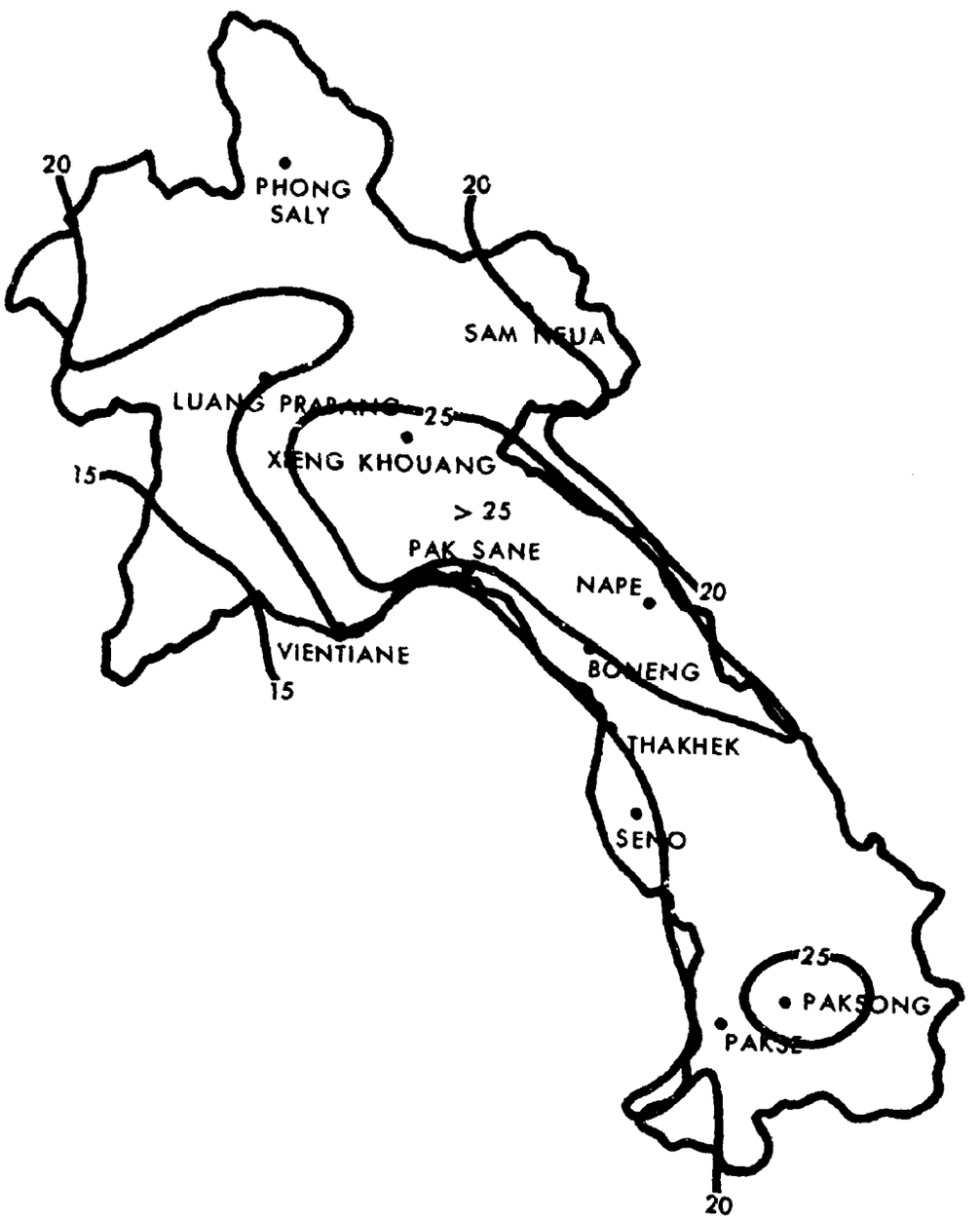


Fig. 9g.

JUL

MEAN PRECIPITATION (in)

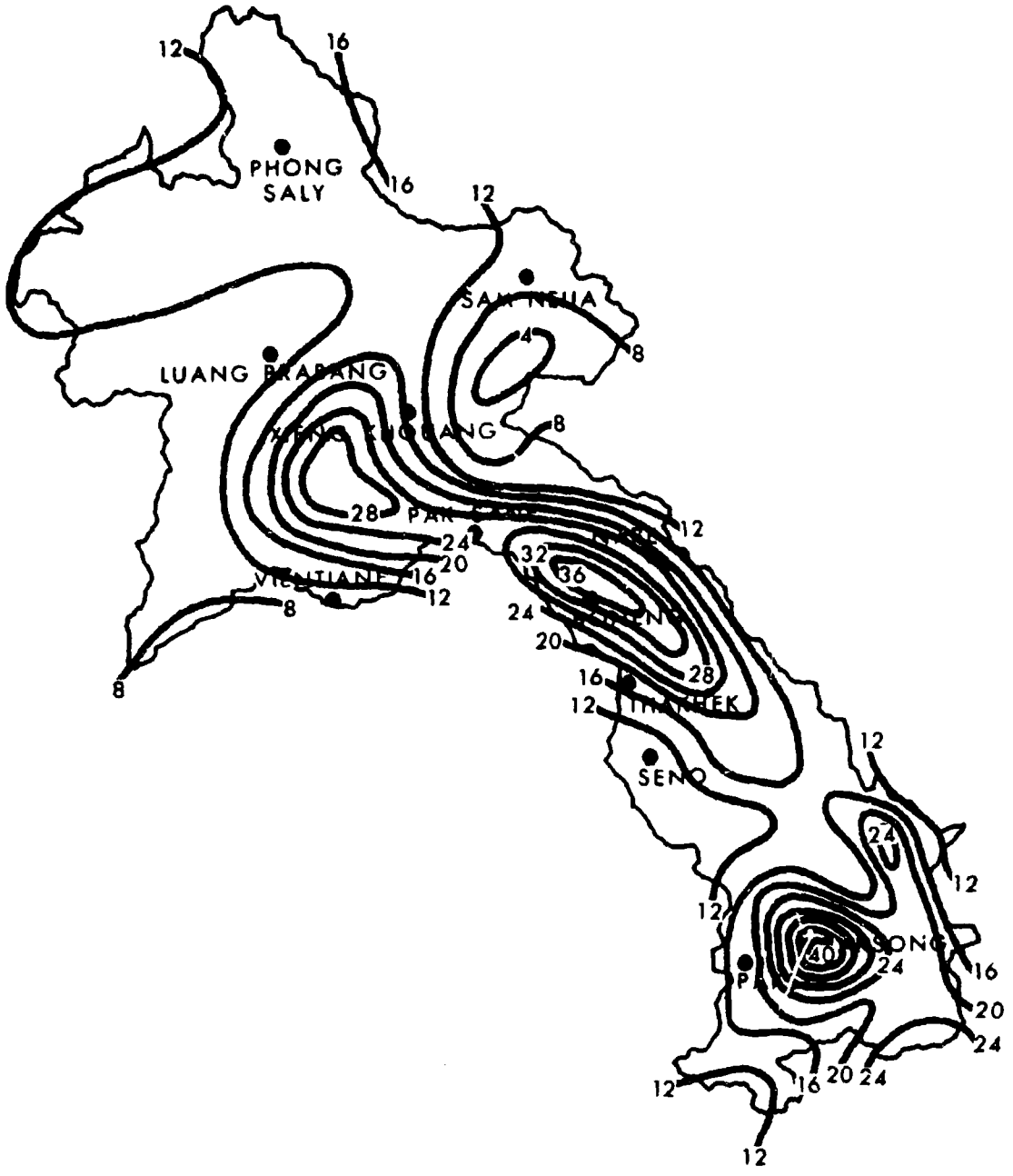


Fig. 10g

JUL

PRECIPITATION and THUNDERSTORMS

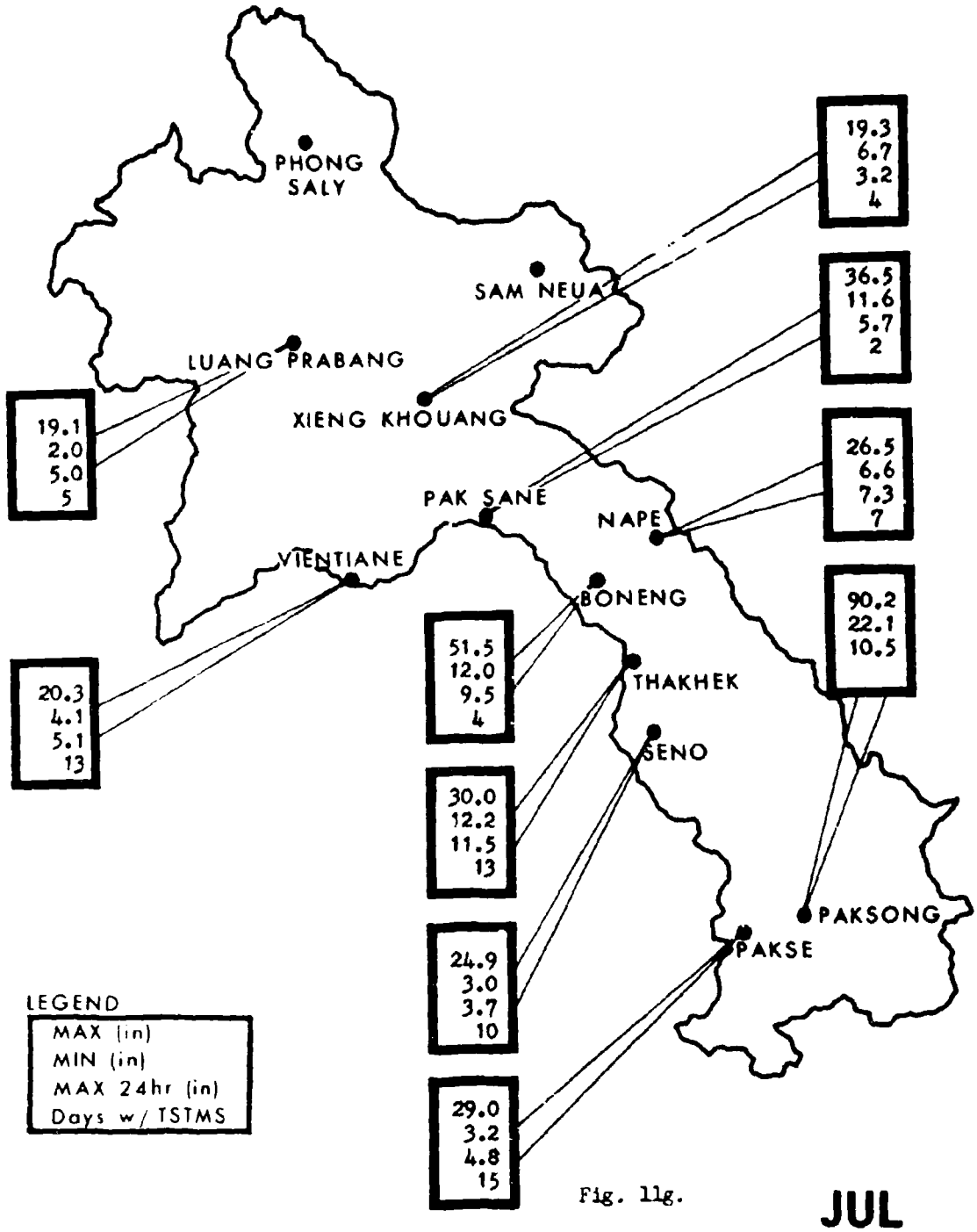


Fig. 11g.

JUL

VISIBILITY

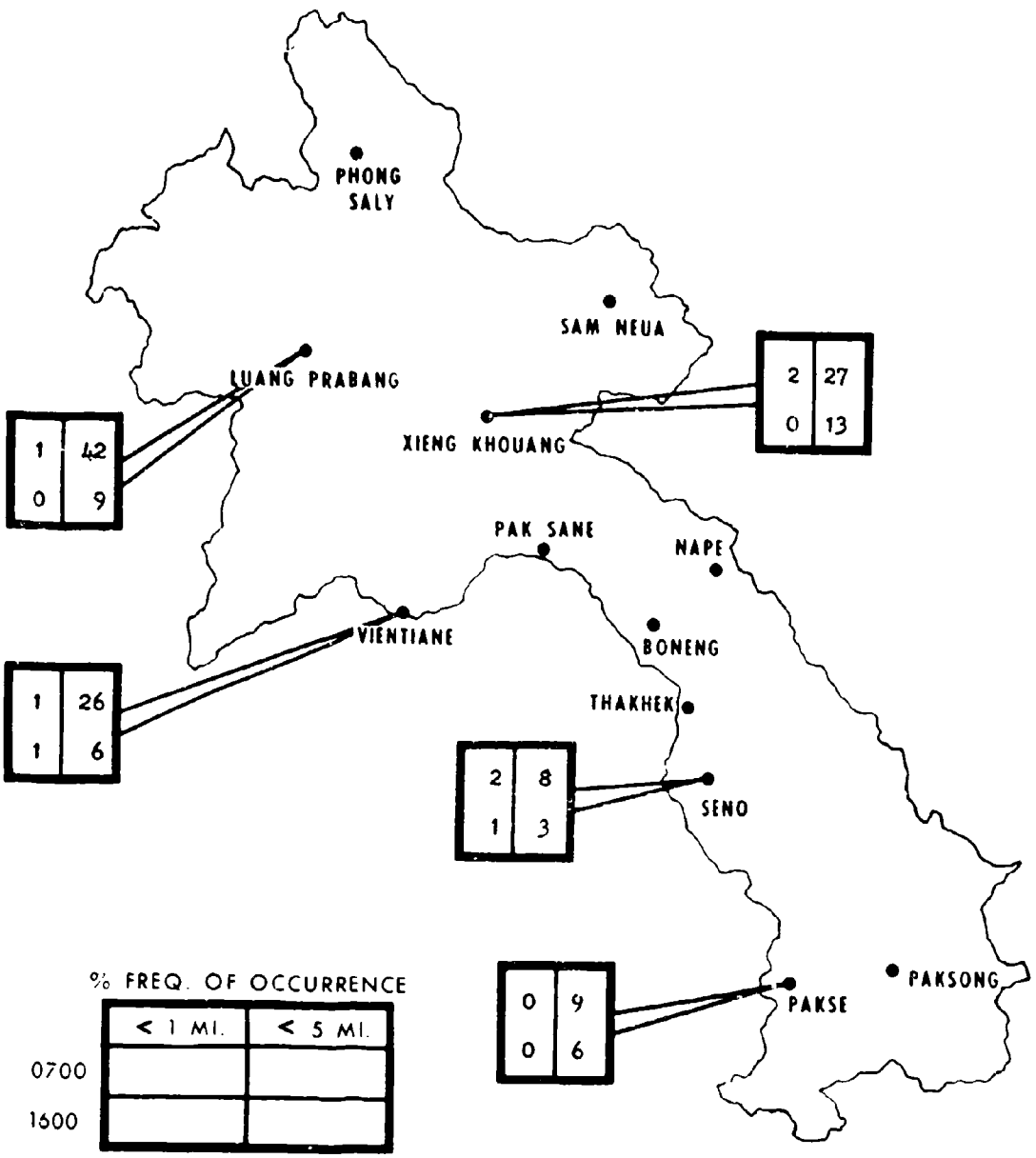


Fig. 12g.

JUL

FOG-SMOKE/HAZE

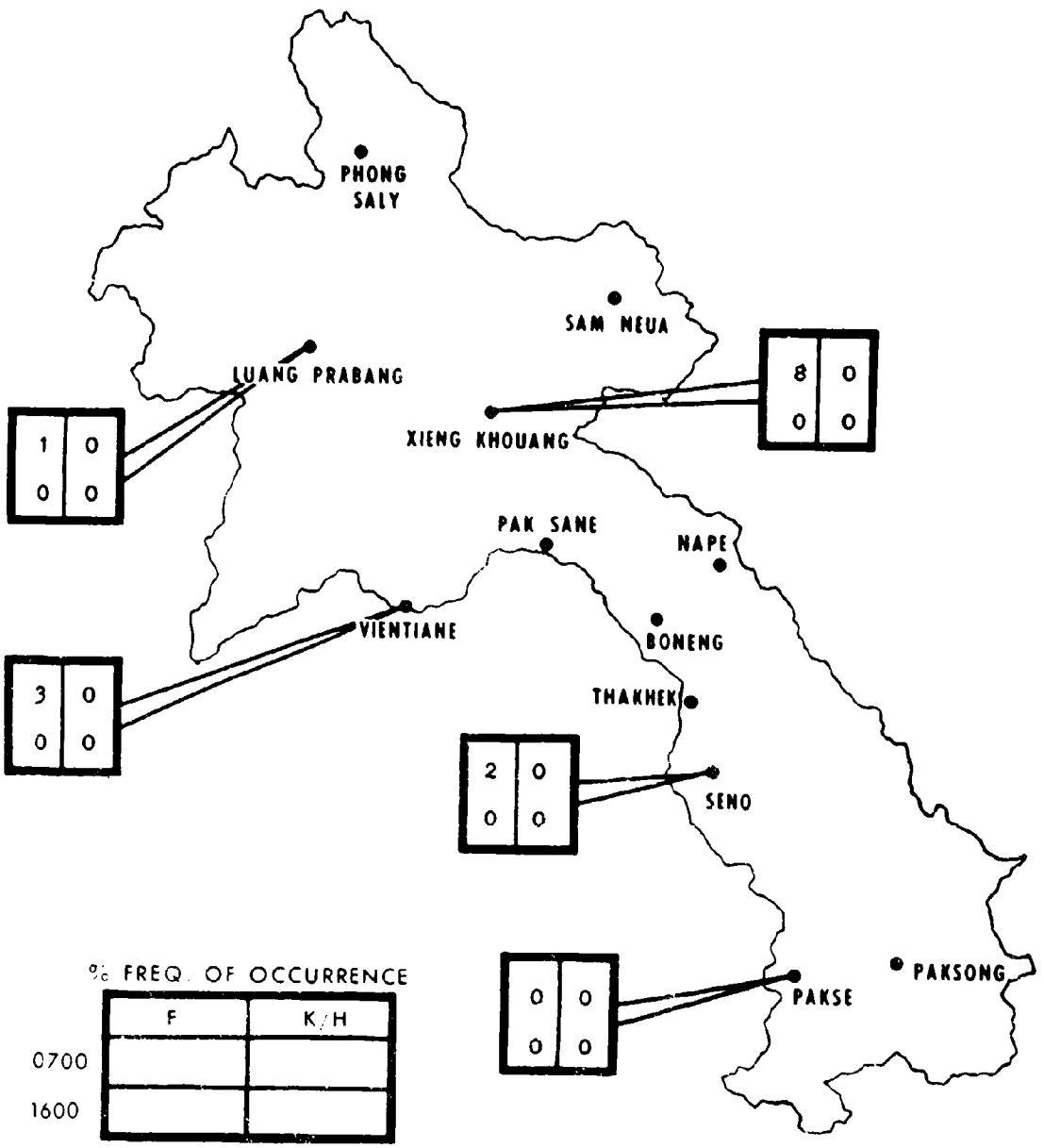


Fig. 13g.

CEILING/VISIBILITY

(0700 LST)

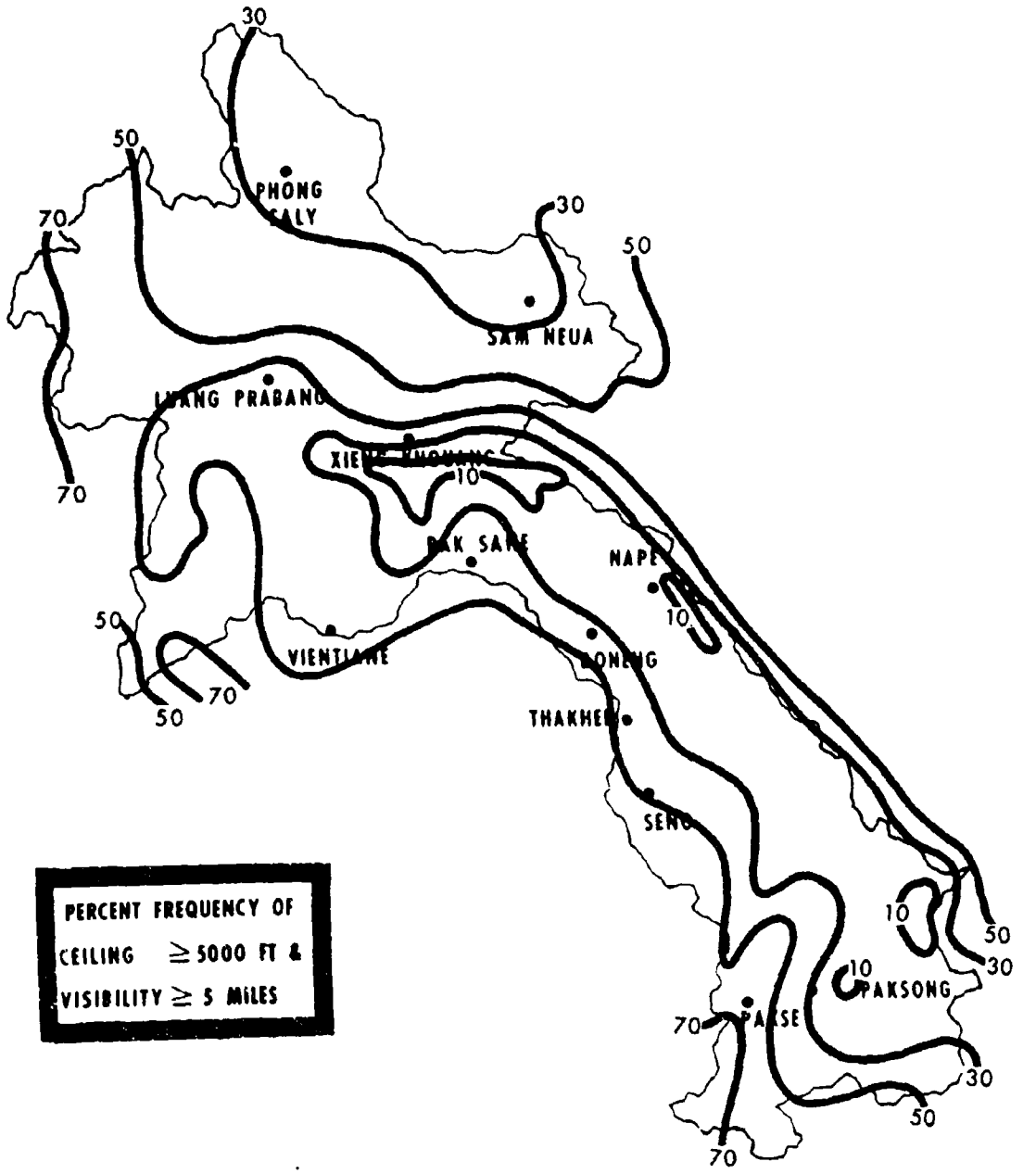


Fig. 14g

JUL

CEILING/VISIBILITY

(1600 LST)

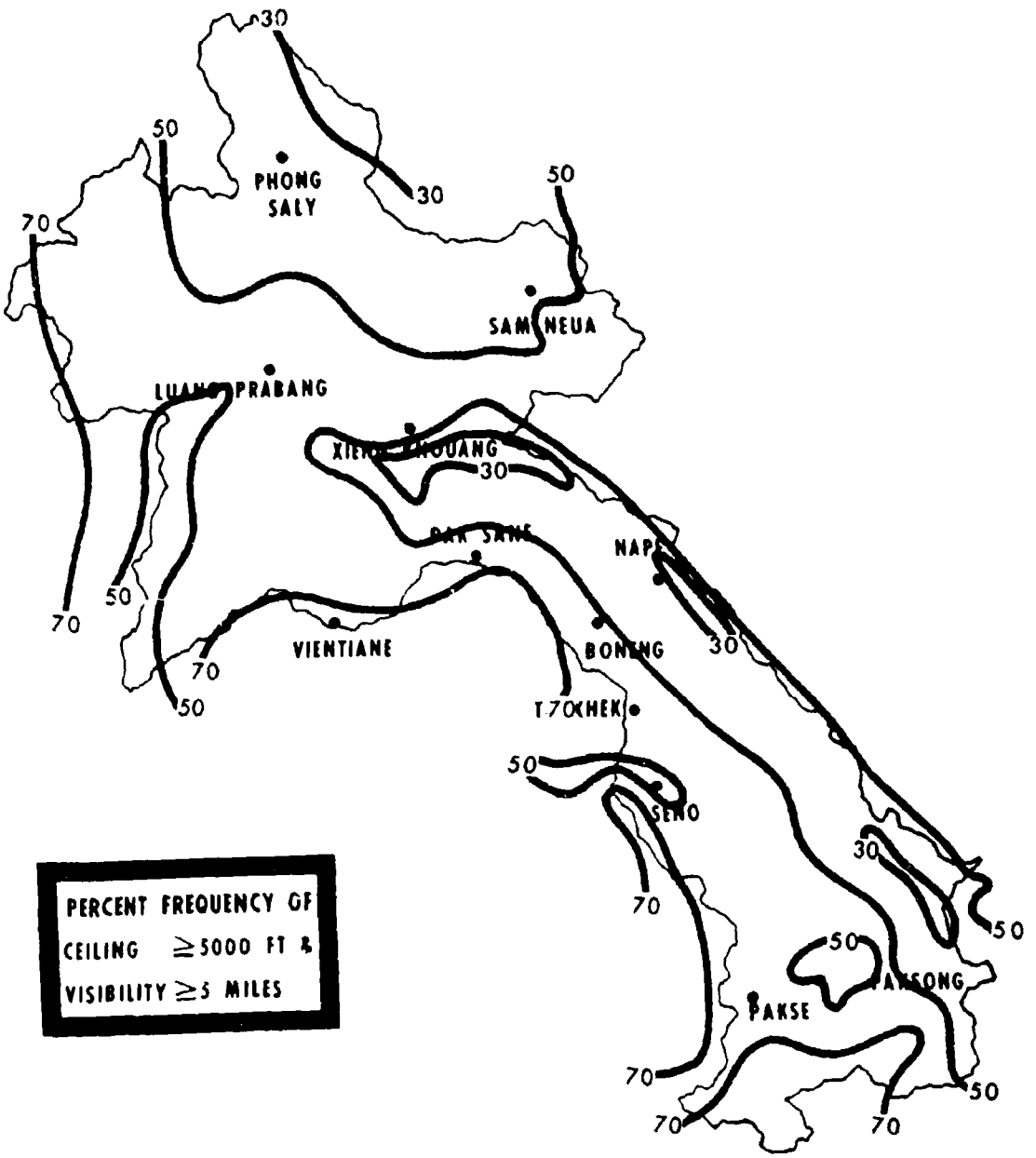


Fig. 15g

JUL

CEILING/VISIBILITY

(0700 LST)

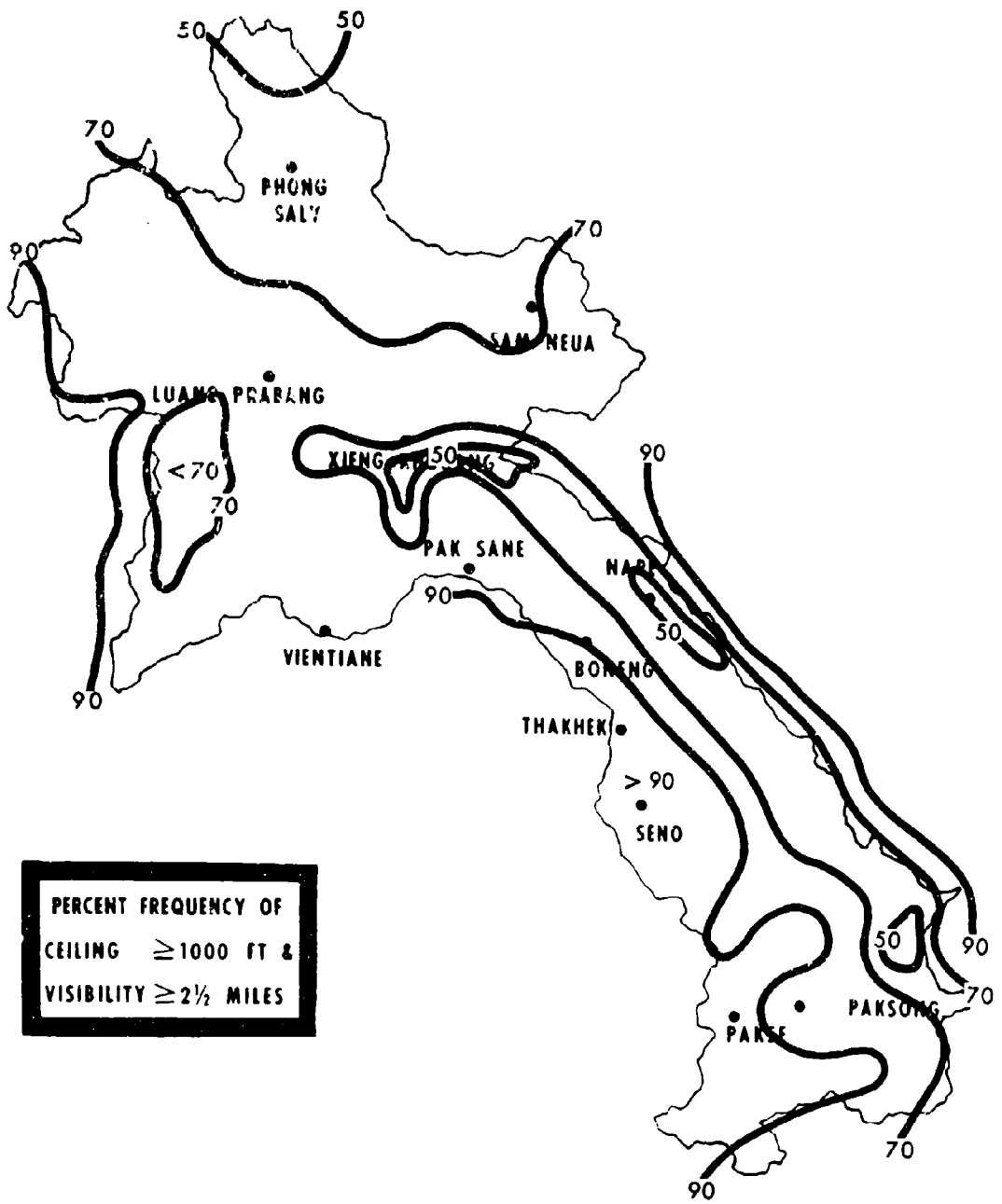


Fig. 16g

JUL

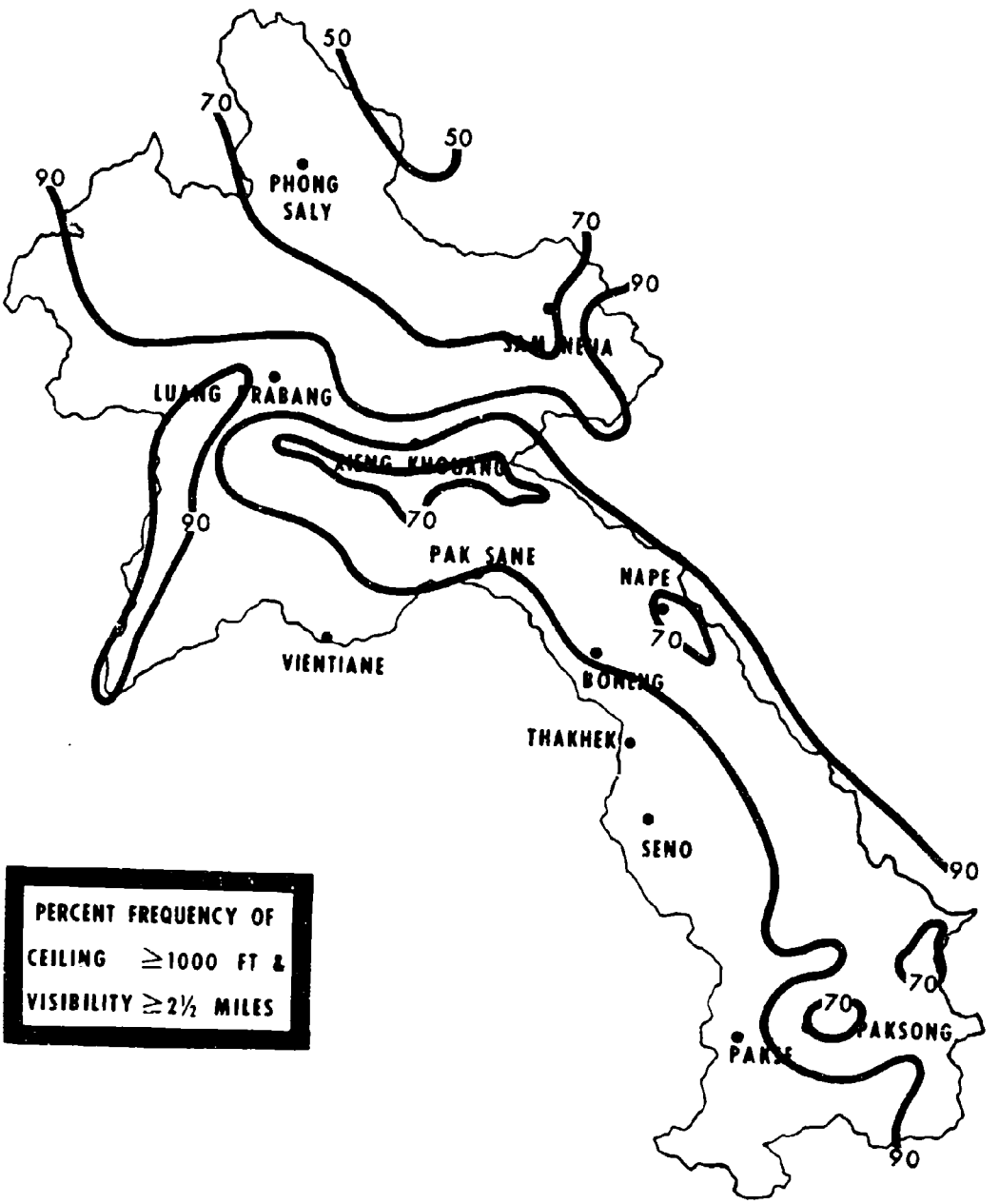

CEILING/VISIBILITY
(1600 LST)
50
70
50
90
PHONG SALY
70
90
LUANG PRABANG
90
70
PAK SANE
NAPE
70
VIENTIANE
THAKHEK
SENO
90
70
70
PAKSONG
90
PERCENT FREQUENCY OF CEILING ≥1000 FT & VISIBILITY ≥2½ MILES
JUL

Fig. 17g

JULY SUNRISE, SUNSET AND TWILIGHT FOR VIENTIANE (17°59'N, 102°34'E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0445	0513	0538	1849	1913	1942	-2.0	2.0
2	0445	0514	0538	1849	1913	1942	-2.0	2.0
3	0445	0514	0538	1849	1913	1942	-2.0	2.0
4	0446	0514	0538	1849	1913	1942	-2.0	2.0
5	0446	0515	0539	1849	1913	1942	-2.0	2.0
6	0447	0515	0539	1849	1913	1942	-1.9	2.0
7	0447	0515	0539	1849	1913	1942	-1.9	2.0
8	0447	0516	0540	1849	1913	1942	-1.9	2.0
9	0448	0516	0540	1849	1913	1942	-1.9	1.9
10	0448	0516	0540	1849	1913	1942	-1.9	1.9
11	0448	0517	0541	1849	1913	1941	-1.9	1.9
12	0449	0517	0541	1849	1913	1941	-1.9	1.9
13	0449	0518	0541	1849	1913	1941	-1.9	1.9
14	0450	0518	0542	1849	1913	1941	-1.9	1.9
15	0450	0518	0542	1849	1913	1941	-1.8	1.8
16	0451	0519	0542	1849	1912	1941	-1.8	1.8
17	0451	0519	0543	1849	1912	1940	-1.8	1.8
18	0451	0519	0543	1848	1912	1940	-1.8	1.8
19	0452	0520	0543	1848	1912	1940	-1.8	1.8
20	0452	0520	0544	1848	1912	1939	-1.8	1.8
21	0453	0521	0544	1848	1911	1939	-1.7	1.7
22	0453	0521	0545	1847	1911	1939	-1.7	1.7
23	0454	0521	0545	1847	1911	1938	-1.7	1.7
24	0454	0522	0545	1847	1910	1938	-1.7	1.7
25	0454	0522	0546	1847	1910	1938	-1.7	1.7
26	0455	0522	0546	1846	1910	1937	-1.6	1.6
27	0455	0523	0546	1846	1909	1937	-1.6	1.6
28	0456	0523	0547	1846	1909	1936	-1.6	1.6
29	0456	0524	0547	1845	1909	1936	-1.6	1.6
30	0456	0524	0547	1845	1908	1935	-1.6	1.6
31	0457	0524	0547	1844	1908	1935	-1.5	1.5

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 18g.

H. AUGUST

1. Climatic Brief: The southwest monsoon continues in full force over all of Laos during August. The weather follows a somewhat regular daily pattern with afternoon showers occurring over parts of the country almost every day. The southwest monsoon is in its third month during August, and river and stream beds are usually filled to overflowing from the heavy precipitation.

Cloudiness reaches its annual maximum; at most locations it averages 80 to 90%. Low ceilings occur on a few mornings, but are relatively rare during the afternoon and evening, except in passing thunderstorms and showers. A normal day will find cumulus clouds forming by mid-morning, lowering and increasing in amount to become broken to overcast by mid-afternoon, then breaking up at night. There is a great deal of middle and high cloudiness over all regions of Laos in August.

Due to the hazy nature of the equatorial air mass, visibilities are almost always somewhat reduced. The lowest visibilities generally occur in showers and thunderstorms. During early morning hours moderately low visibilities frequently occur in haze and smoke near heavily populated areas, and with stratus clouds that form on windward mountain slopes.

Topography is a major factor in determining the distribution of precipitation, but in general, the rainfall regime remains the same in August as it was in July. Locations just upstream of sudden rises in surface relief, as well as locations on exposed mountain slopes and plateaus, average from 22 to 34 in. of precipitation over a period of 23 to 27 days. Amounts of greater than 50 in. for the month and greater than 10 inches in one day have been recorded. Locations to the lee of mountains and in deep sheltered valleys average 3 to 8 in. of rain over a period of 10 to 15 days.

Most precipitation occurs in showers and thunderstorms. Although there is a slight decrease in thunderstorm activity over most of the area during August, thunderstorms are usually intense and are often accompanied by strong surface winds. Nocturnal thunderstorms are a significant feature in the Mekong River Valley. These are usually intense but of short duration.

Mean temperatures at most locations show very little change in August from those experienced in July. In the afternoon temperatures average in the high 80's and at night fall to the mid 70's. Humidity is high everywhere, and averages a damp 80 to 90%.

2. Temperatures: Temperatures show very little change in August from those experienced in July. No data are available for the region north of 20°N; however, available data from neighboring countries indicate that maximum temperatures in this region range from near 75 to 82F. Maximums in this temperature range also occur at higher elevations in the southern panhandle. Mean maximums over the remainder of the

country are between 84 and 89F. The highest reported mean maximum is 89F at Luang Prabang. The lowest mean maximum is 74F at Pak Song. The extreme high temperature on record is 101F at Luang Prabang.

Mean daily minimum temperatures usually follow the same areal pattern as that of the maximums. Minimums range from 65 to 70F in the northern mountains to over 75F along the Thailand border. The highest recorded mean minimum is 77F at Boneng and the lowest is 65F at Pak Song. The extreme low temperature is 54F at Xieng Khouang. (See Fig. 7h.)

3. Relative Humidity: Over Laos relative humidity remains at a mid-summer maximum during August. Mean humidity values over most of Laos are between 80 and 90%. The highest mean humidity is 88% at Luang Prabang and the lowest is 82% at Seno. The record low humidity is 32% at Pakse. The high humidity results in conditions favorable for mildew, corrosion, and decay of susceptible items. Highest daily humidities occur during the early morning hours and after rainshowers. The high humidities tend to make the high temperatures seem ever higher. (See Fig. 8h.)

4. Precipitation and Thunderstorms: August is a wet season month throughout Laos. Two to 3 days with rainfall amounts in excess of 1 in. can be expected at most locations. Daily amounts in excess of 2 in. can be expected on an average of 2 days on the Boloven's Plateau. Precipitation occurs on more than 15 days of the month over all regions. The rainiest part of the country is over the central panhandle and north of the Boloven's Plateau. In these areas mean values are 30 to 35 in., with precipitation occurring on more than 25 days. The driest area occurs along the Mekong River valley in the northwest, where, although rain falls on 20 or more days, mean amounts are under 15 in.

The variability in rainfall is evident by the large variation in maximum and minimum August precipitation amounts. In the north, minimum values range from 2 to 8 in. and maximums are 30 to 50 in. The greatest variation occurs over windward slopes in the southern panhandle, where minimum monthly amounts are below 16 in. and maximums are above 60 in. Observed maximum 24-hr rainfall values range from 3 in. at Khong, in the extreme south to 14 in. at Attopeu, 70 mi east of Pakse, but most stations report 24-hr maximums of 4 to 9 in.

In August most thunderstorm activity is the result of combined afternoon convection and orographic lifting. Thundershowers normally occur during the late afternoon and generally last only a few hours. In Laos, maximum activity, 10 to 15 thunderstorm days, occurs in the northwestern mountains and along the southwest border. Minimum activity, less than 5 thunderstorm days, occurs over the Plaine of Jarres. (See Figs. 9h, 10h and 11h.)

5. Cloudiness: Cloudiness reaches its annual maximum in August and averages between 80 and 95% everywhere. Most cloudiness is caused by orographic lifting of warm, moist air as it approaches the Annam Range.

Mountain tops are frequently obscured as cloud masses build on windward slopes. Convective clouds form during the late morning hours, and 2,000 to 3,000 ft ceilings are frequent in the afternoon. Broken cloud layers, with bases between 8,000 and 15,000 ft, are associated with afternoon and evening thunderstorms, but related low cloudiness dissipates rapidly after sunset. Cirrus clouds above 30,000 ft are common over Laos.

6. Visibility and Obstructions to Vision: Early morning visibilities of 1 to 3 mi occasionally occur in valley fog in the northern mountains, and in haze and smoke near heavily populated areas. Morning fog conditions seldom last beyond 0900 LST. In mountain valleys north of 20°N and on exposed slopes of the Annam Range, fog occurs on 5 to 7 days, but over the rest of Laos fog is observed on 2 days or less. Showers and thundershowers reduce visibilities to less than 5 mi for brief periods, and in more intense storms, to less than 1 mi. Slant range visibility shows little improvement; for as the occurrence of haze and smoke decrease, the frequency of convective cloudiness and showers increases. Visibilities greater than 12 mi are not common anywhere over Laos. (See Figs. 12h and 13h.)

7. Wind and Temperatures Aloft: Mean low-level winds are southwesterly over almost all of Laos, but there is a slight decrease in speeds from those of July. Local surface winds, both directions and speeds, are influenced by local topography and can deviate significantly from mean winds. Most cases of strong gusty surface winds are associated with thunderstorm activity, but high winds can be caused by channeling (Venturi effect). Channeling can be expected in mountain regions where valleys or passes face the prevailing wind. The winds are compressed and packed, and the speeds increased as they flow through the narrow confines. There is insufficient Laotian data upon which to base firm estimates of extreme wind speeds over Laos but winds of 70 kt have been observed under similar conditions in Vietnam.

Gusty surface winds associated with thunderstorm activity do occur and gusts greater than 60 kt have been recorded in both highlands and lowlands in Vietnam and such should be expected on occasion over Laos. Maximum surface winds generally occur between 1000 and 1800 LST, the period of maximum convective activity.

Westerly to southwesterly winds extend aloft to about 15,000 ft over most of Laos. Above this, easterly to northeasterly winds prevail to above 40,000 ft. Upper air temperatures are close to -18C at 25,000 ft throughout the year. During August the mean freezing level over Laos ranges from about 17,500 ft in the north to 15,500 ft in the south.

8. Combined Ceiling and Visibility: Combined ceilings and visibilities are poorest during the early morning hours near sunrise with visibilities being the major restrictant. Ceilings of 5,000 ft or more accompanied by visibilities of at least 5 mi ($\geq$5000/5) occur less than 10% of the time over the higher elevations along the eastern border region and the Boloven's Plateau near Pak Song. The best region at this time of day is along the Mekong River, particularly southwest of Pakse where

percentages as high as 70% can be found. By mid-afternoon some slight improvement takes place, particularly in the regions of lowest frequency but there is little change in the overall pattern, with conditions along the Mekong continuing to be the best in the country. Improvements in visibility between morning and afternoon are generally offset by an increase in frequency of ceilings below 5,000 ft after 1000 LST.

The frequency of $\geq$1000/2 1/2 is also at a minimum during the early hours and is somewhat less than 50% along higher elevations of the eastern border regions and north of 21°N latitude. Over much of the Mekong Valley south of Pak Sane the frequency is about 90%. By mid-afternoon some improvement takes place, particularly in the regions of of lowest frequency but elsewhere there is little change. By 1600 LST frequencies lower than 50% are confined to the higher ridges of the Chaine Annamatique and the region north of Phong Saly.

TEMPERATURE (°F)

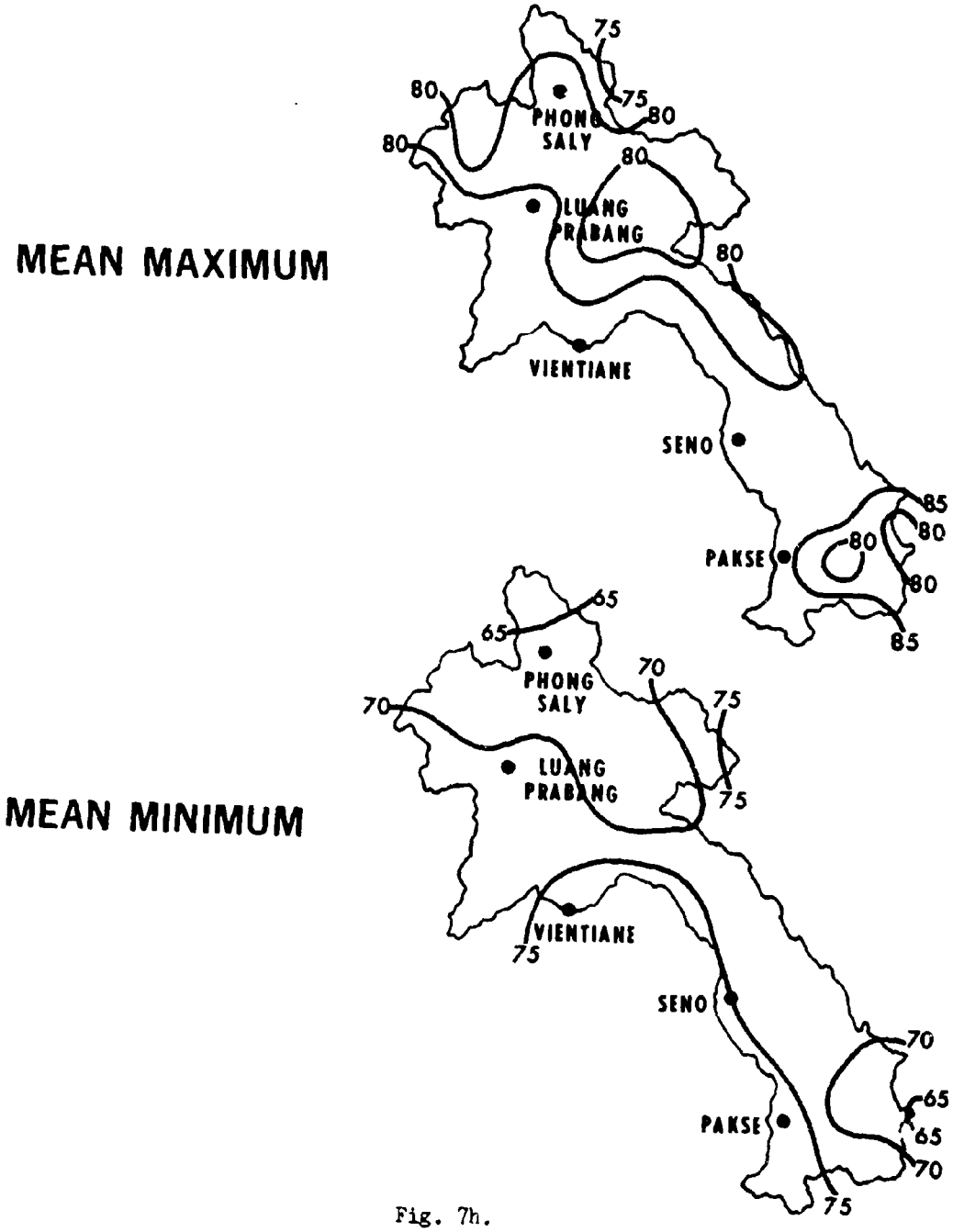


Fig. 7h.

MEAN RELATIVE HUMIDITY (%)

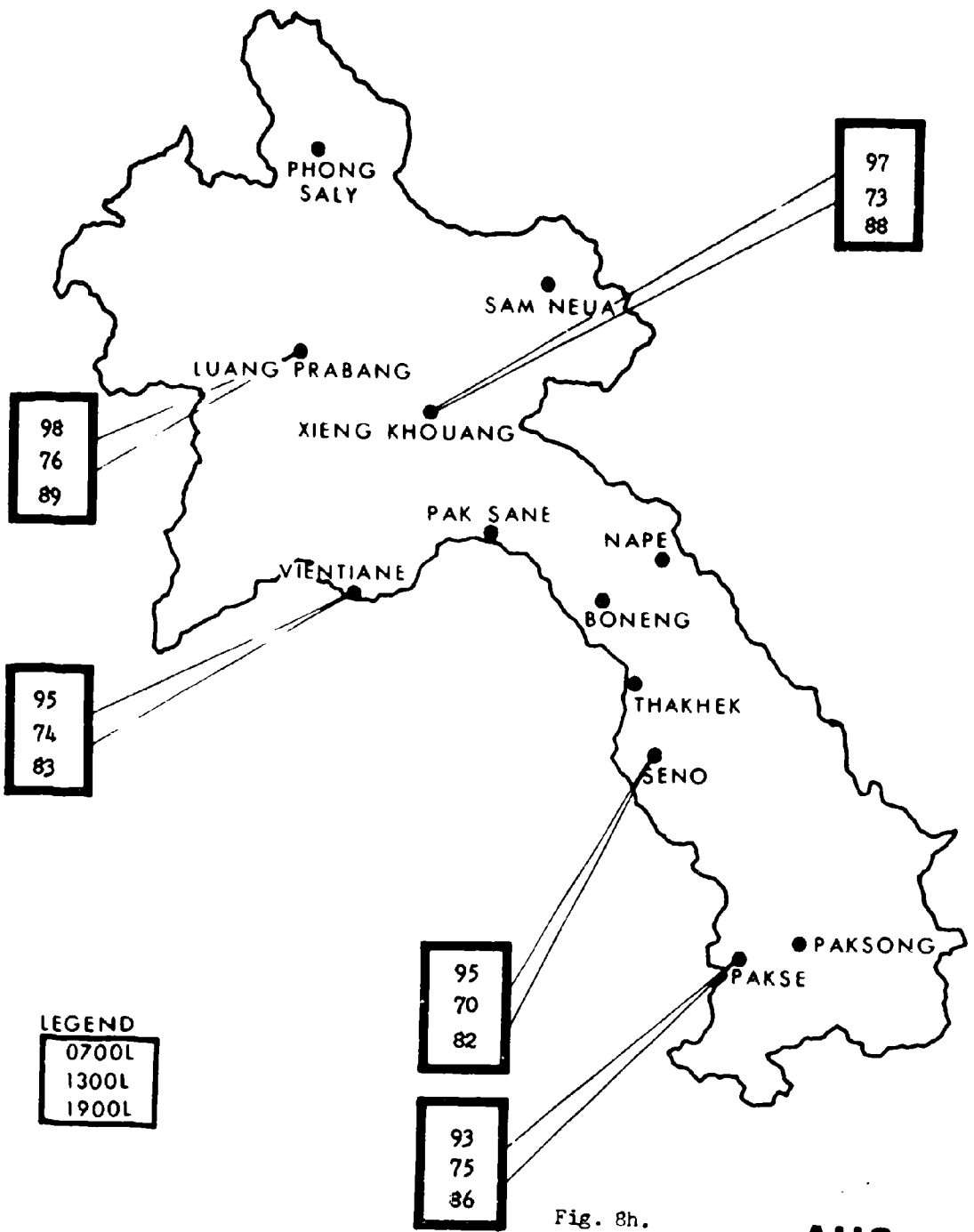


Fig. 8h.

AUG

MEAN NUMBER OF DAYS WITH PRECIPITATION

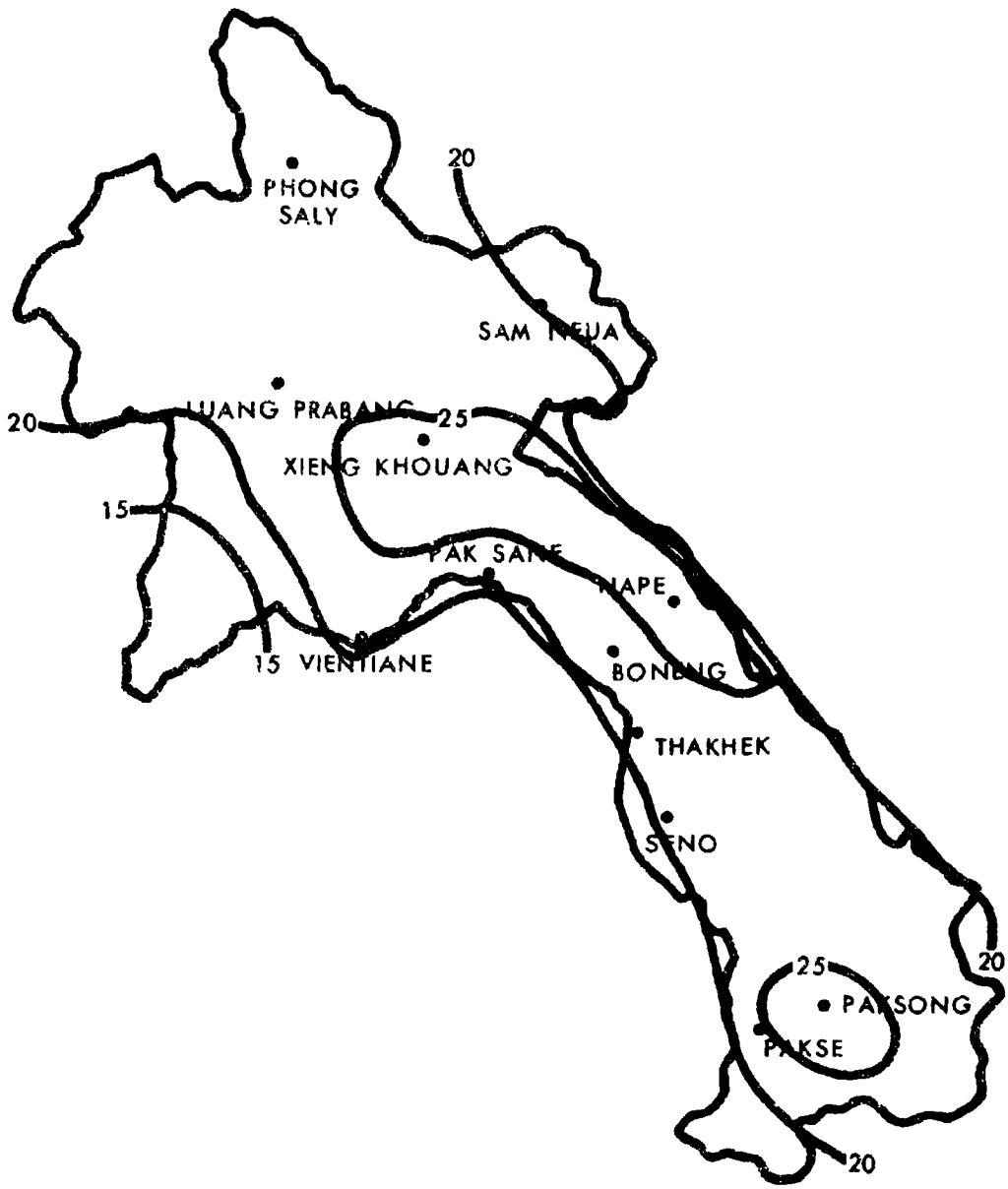


Fig. 9h.

AUG

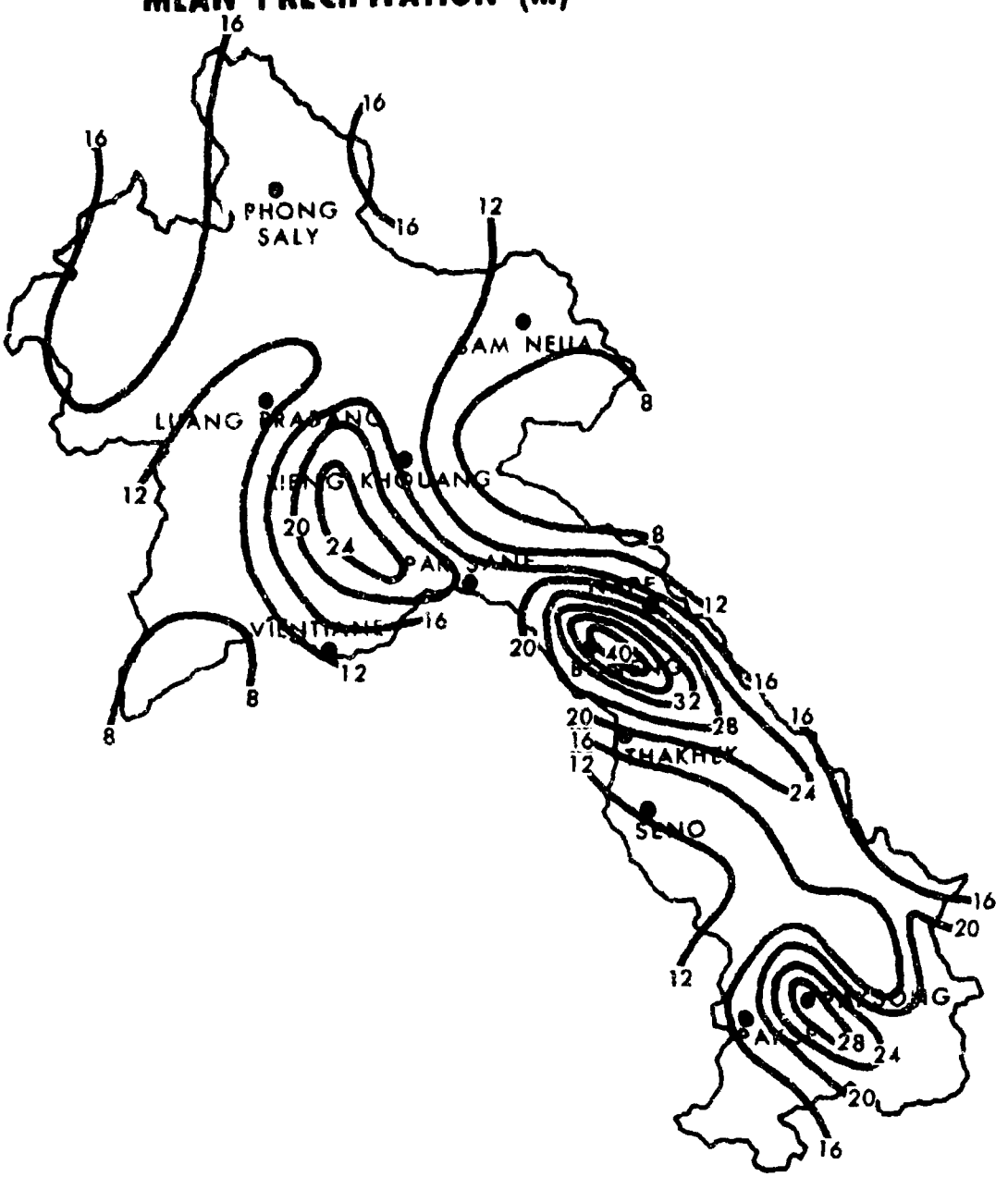

MEAN PRECIPITATION (in)
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
VIENTIANE
THAKHEK
SENO
AUG

Fig. 10h

PRECIPITATION and THUNDERSTORMS

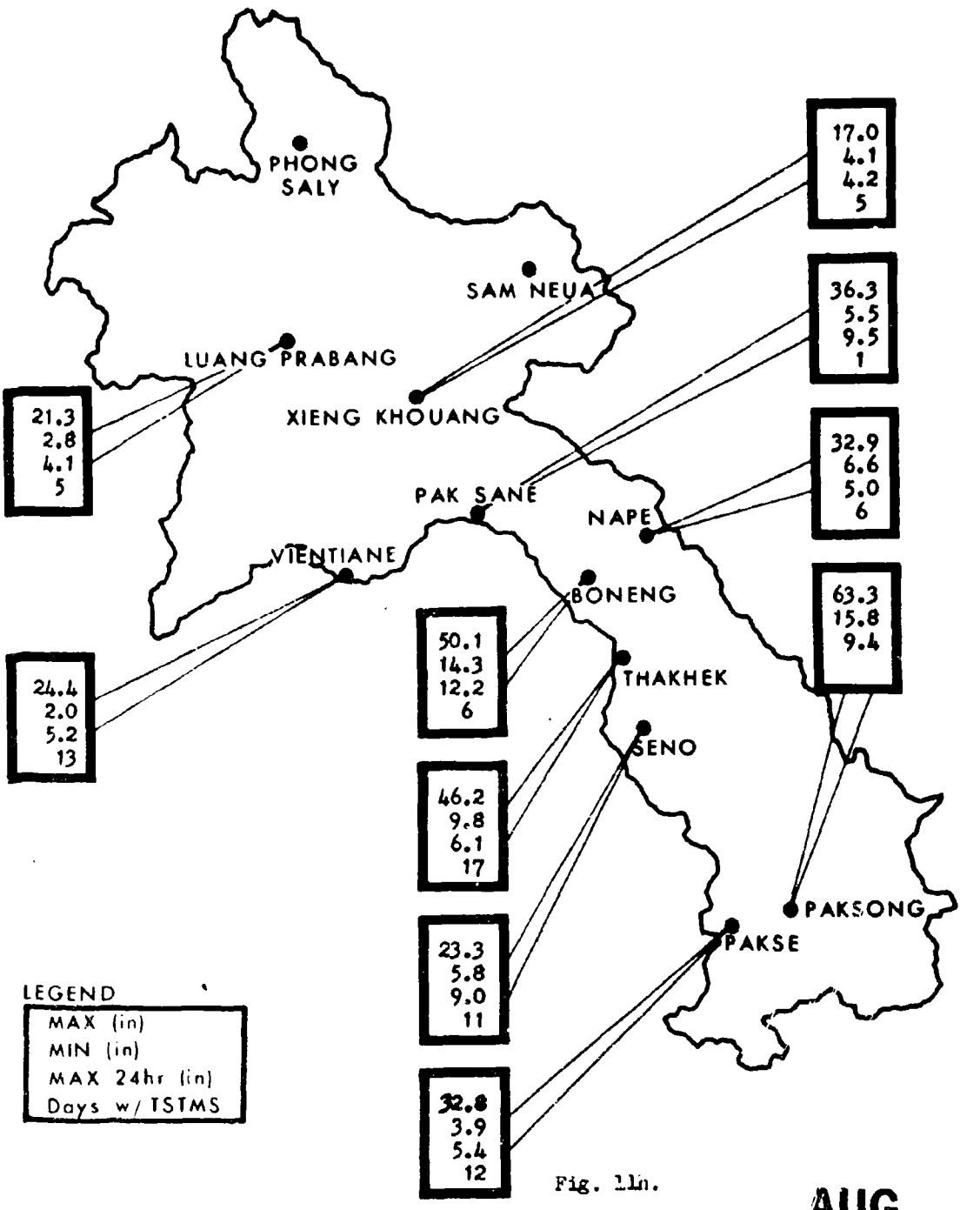
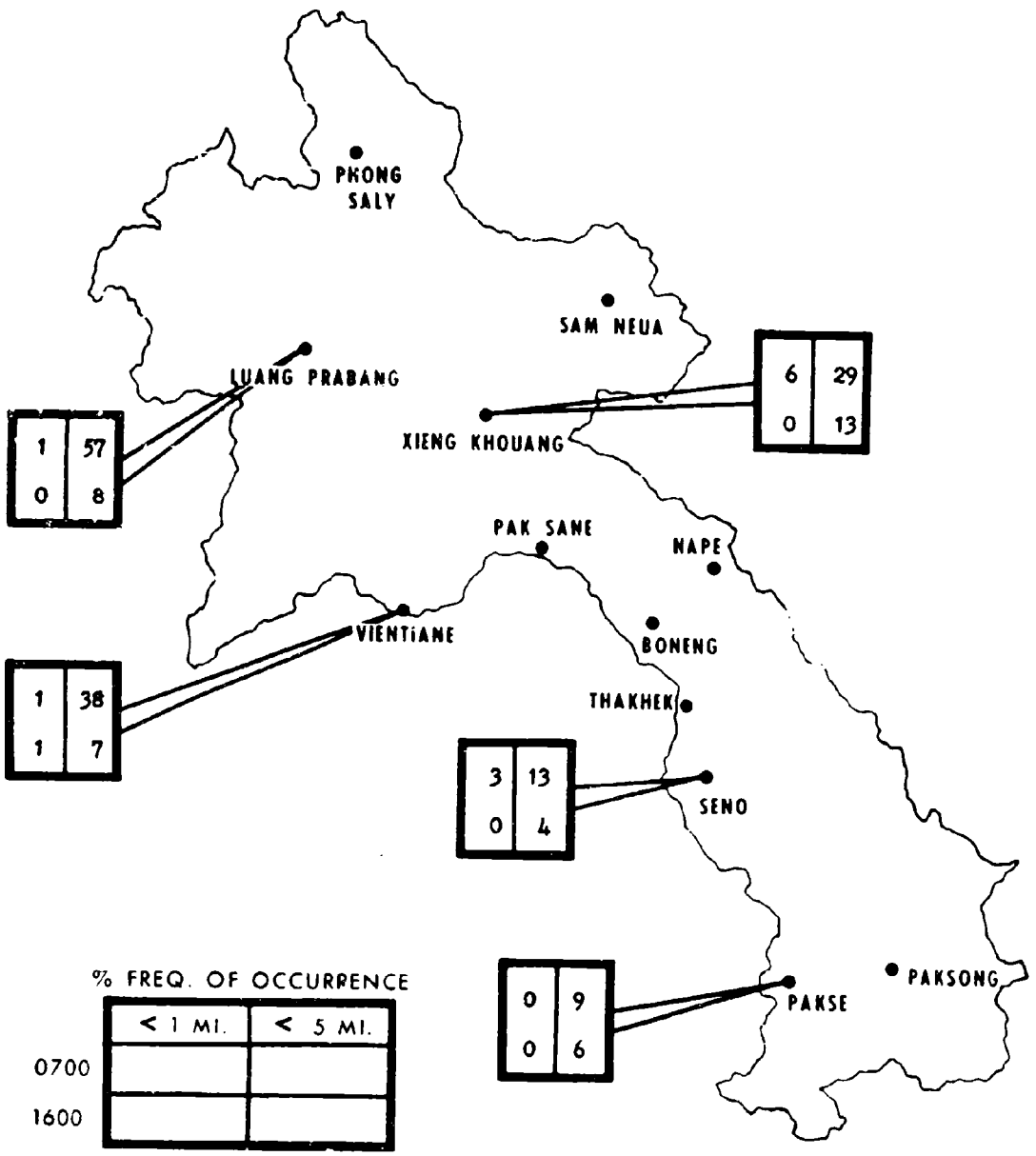


Fig. 11n.

AUG

VISIBILITY



% FREQ. OF OCCURRENCE

	< 1 MI.	< 5 MI.
0700		
1600		

Fig. 12h.

AUG

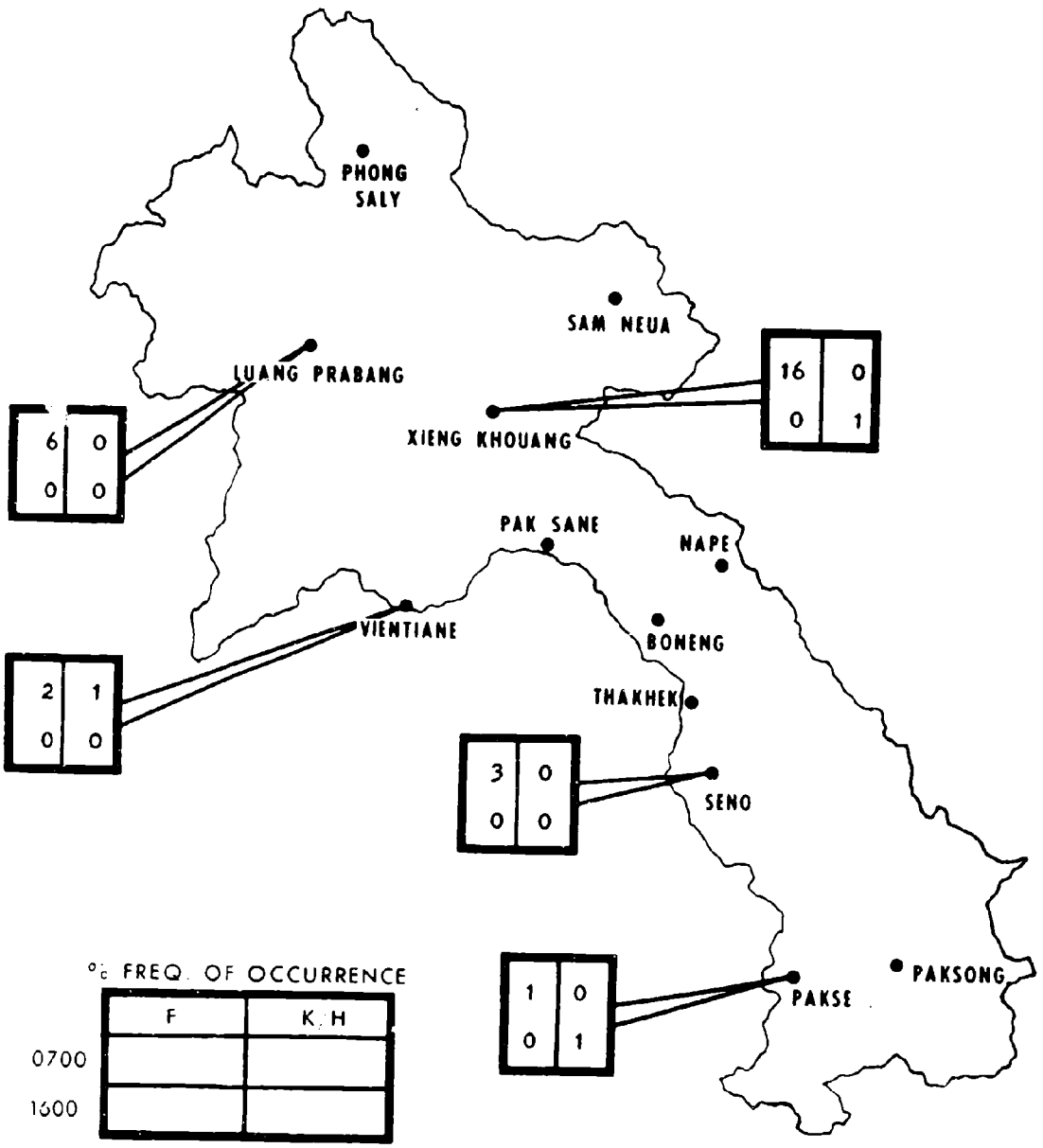

FOG-SMOKE/HAZE
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
PAKSE
6 0
0 0
16 0
0 1
2 1
0 0
3 0
0 0
1 0
0 1
°c FREQ. OF OCCURRENCE
F
K.H
0700
1600
AUG

Fig. 13h.

CEILING/VISIBILITY

(0700 LST)

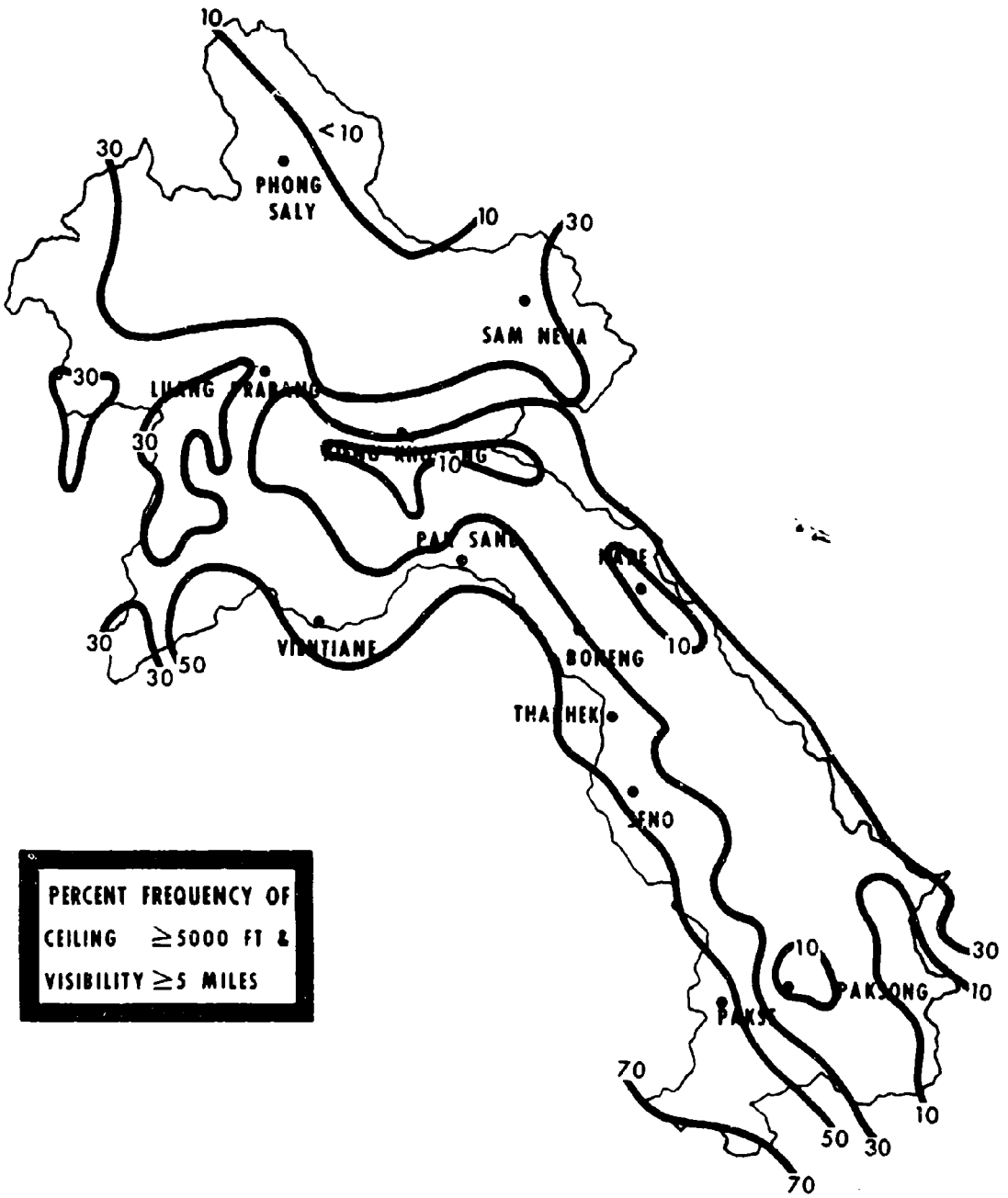


Fig. 14h

AUG

CEILING/VISIBILITY

(1600 LST)

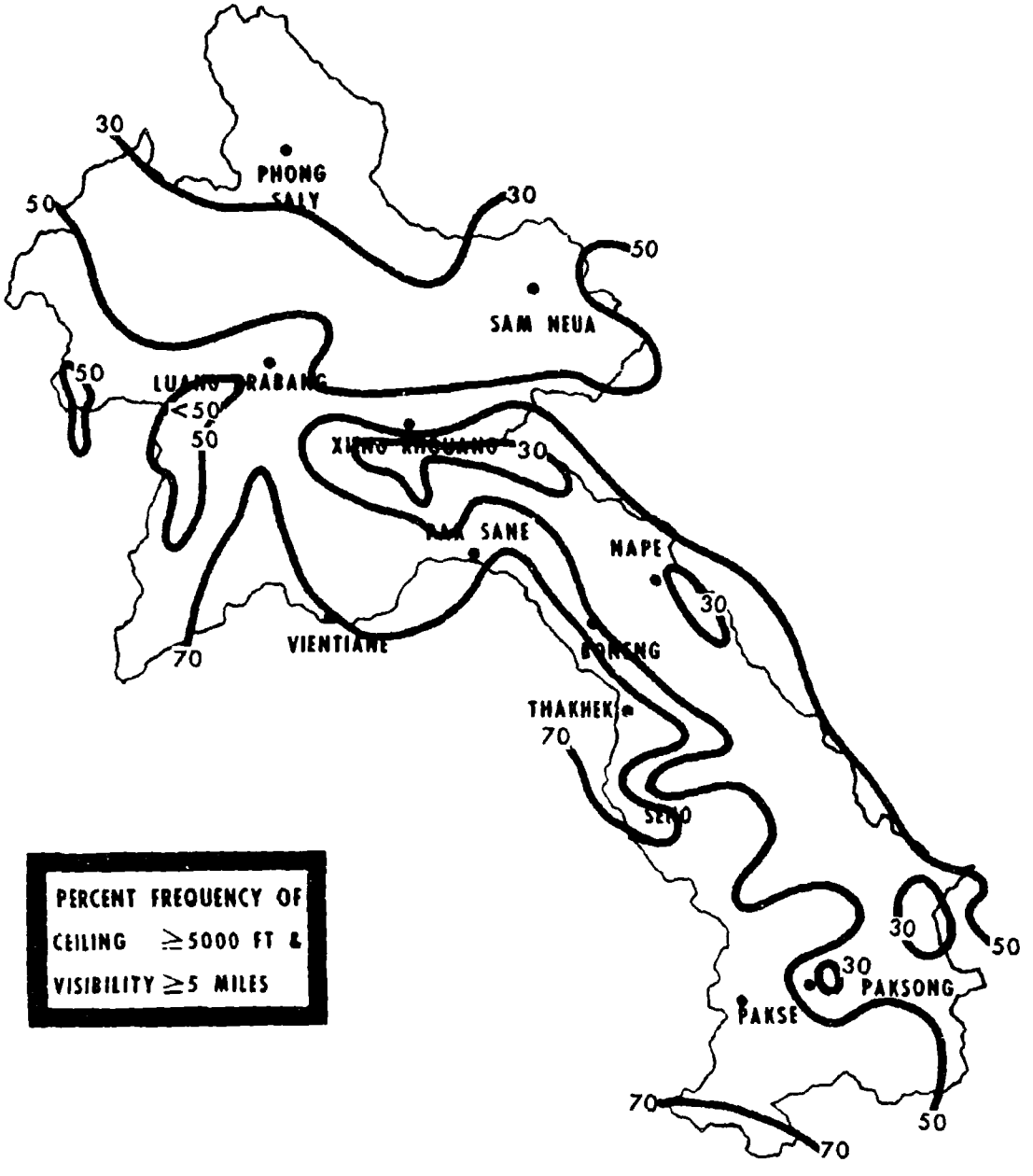


Fig. 15h

AUG

CEILING/VISIBILITY

(0700 LST)

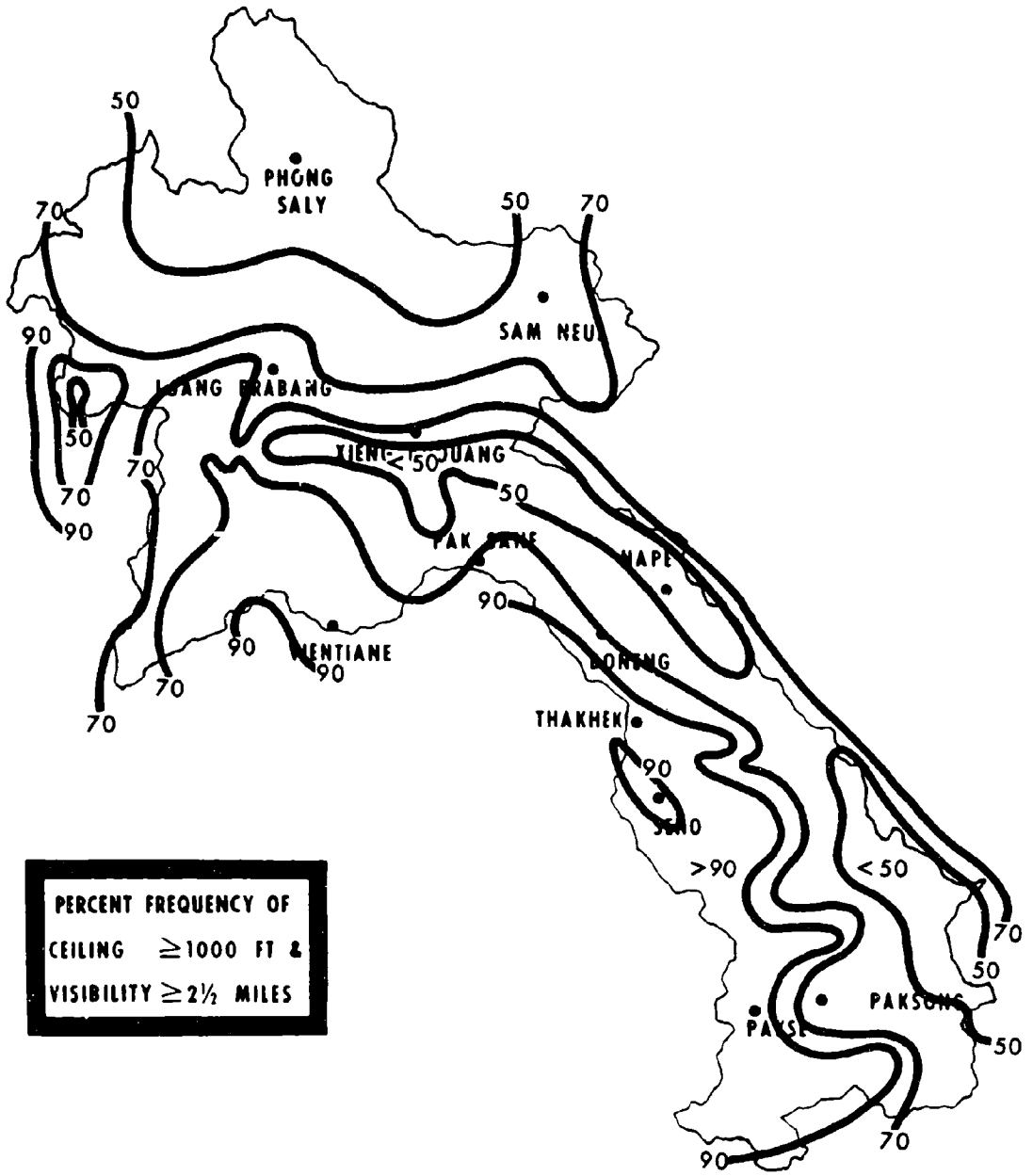


Fig. 16h

AUG

CEILING/VISIBILITY

(1600 LST)

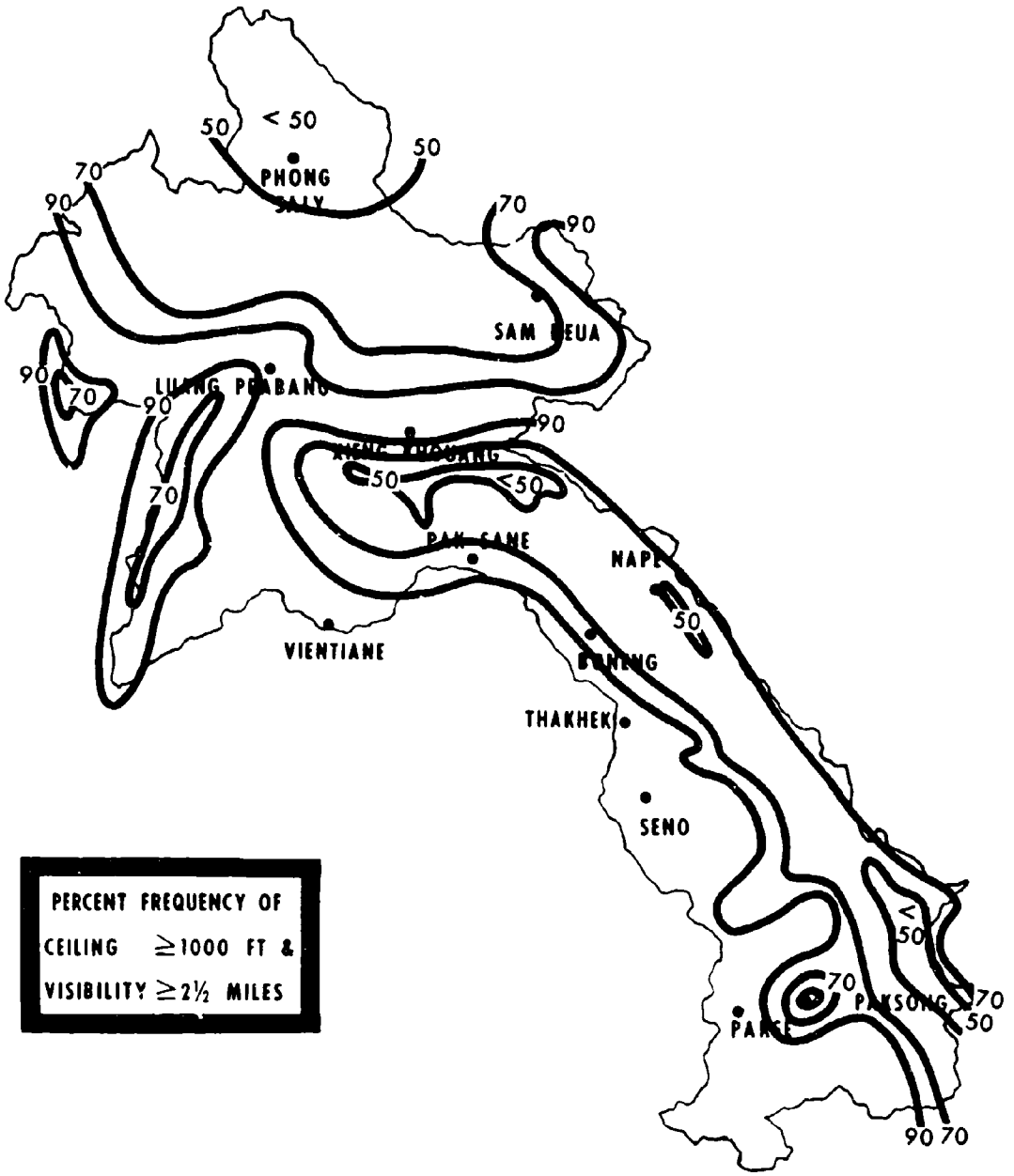


Fig. 17h

AUG

AUGUST SUNRISE, SUNSET AND TWILIGHT FOR VIENTIANE (17°59'N, 102°34'E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0457	0525	0548	1844	1907	1934	-1.5	1.5
2	0458	0525	0548	1844	1907	1934	-1.5	1.5
3	0458	0525	0548	1843	1906	1933	-1.5	1.5
4	0458	0526	0549	1843	1906	1933	-1.4	1.4
5	0459	0526	0549	1842	1905	1932	-1.4	1.4
6	0459	0526	0549	1842	1905	1932	-1.4	1.4
7	0500	0527	0550	1841	1904	1931	-1.4	1.4
8	0500	0527	0550	1841	1904	1930	-1.3	1.3
9	0500	0527	0550	1840	1903	1930	-1.3	1.3
10	0501	0528	0550	1840	1902	1929	-1.3	1.3
11	0501	0528	0551	1839	1902	1928	-1.3	1.2
12	0501	0528	0551	1838	1901	1928	-1.3	1.2
13	0502	0529	0551	1838	1900	1927	-1.2	1.2
14	0502	0529	0551	1837	1900	1926	-1.2	1.2
15	0503	0529	0552	1837	1859	1926	-1.2	1.1
16	0503	0529	0552	1836	1859	1925	-1.2	1.1
17	0503	0530	0552	1835	1858	1924	-1.1	1.1
18	0503	0530	0552	1835	1857	1924	-1.1	1.0
19	0504	0530	0553	1834	1856	1923	-1.1	1.0
20	0504	0530	0553	1833	1856	1922	-1.0	1.0
21	0504	0531	0553	1833	1855	1921	-1.0	1.0
22	0505	0531	0553	1832	1854	1920	-1.0	0.9
23	0505	0531	0554	1831	1853	1920	-0.9	0.9
24	0505	0531	0554	1830	1853	1919	-0.9	0.9
25	0506	0532	0554	1830	1852	1918	-0.9	0.8
26	0506	0532	0554	1829	1851	1917	-0.9	0.8
27	0506	0532	0554	1828	1850	1916	-0.8	0.8
28	0506	0532	0555	1827	1850	1916	-0.8	0.8
29	0507	0533	0555	1827	1849	1915	-0.8	0.7
30	0507	0533	0555	1826	1848	1914	-0.7	0.7
31	0507	0533	0555	1825	1847	1913	-0.7	0.7

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 18h.

I. SEPTEMBER

1. Climatic Brief: During the first half of September all of Laos remains under the influence of the southwest monsoon. Traces of the northeast monsoon begin to appear later in the month particularly over the northern half of the country. This is the beginning of the autumn transition season; the period when neither monsoonal flow is predominant, and the Intertropical Convergence Zone (ICZ) begins its southward migration. The autumn transition is the shortest of the four seasons and usually lasts from mid-September to mid-October.

During the latter part of September there is a significant decrease in cloudiness over northern Laos as this region comes under the influence of the northeast monsoon. However, as the ICZ passes, local cloudiness increases temporarily due to increased thunderstorm activity. A normal day will find cumulus clouds forming by mid-morning, lowering and increasing in amount to become broken to overcast by mid-afternoon, then breaking up at night. There is a great deal of middle and high cloudiness over all regions of Laos in September.

During the first part of September visibilities are always somewhat reduced because of the hazy nature of the equatorial air mass. The lowest visibilities generally occur in showers and thunderstorms. During early morning hours moderately low visibilities frequently occur in haze and smoke near heavily populated areas, and with stratus clouds that form on windward mountain slopes. When the autumn transition seasons begins, surface visibility improves greatly. The improved surface visibility together with decreasing low cloudiness results in frequent periods of favorable weather for all types of operations.

During the first half of September the southwest monsoon is still dominant, and the precipitation pattern is similar to that of August. During the latter half of the month rainfall decreases everywhere over Laos. Topography continues to be one of the major factors in determining the distribution of precipitation. There is an overall decrease in thunderstorm activity since the autumn transition season is relatively dry, but temporary increases in thunderstorm activity occur in regions under the influence of the ICZ. Many locations experience 7 to 10 days of heavy precipitation during this period.

Mean temperatures show little change over Laos from August to September. There is a slight drop in minimum temperatures but this is offset by a slight rise in maximums brought about by the decrease in cloudiness. There is little change in humidity from August to September although some drying or decreasing humidities can be noted in the northern part of the country during the latter part of the month.

2. Temperatures: No temperature data are available for the region north of 20°N, but available data from neighboring countries indicate that maximum temperatures in this region range from near 75 to 82F. Maximums in this temperature range also occur at higher elevations in the southern

panhandle. Mean maximums over the remainder of the country are between 84 and 89F. The highest reported mean maximum is 91F at Luang Prabang; the lowest mean maximum is 74F at Pak Song (elevation 3937 ft). The extreme high temperature is 100F at Luang Prabang and Boneng.

Mean daily minimum temperatures usually follow the same areal pattern as that of the maximums, and range from the mid-60's to the mid-70's over most of the country. The lowest reported mean minimum is 63F at Pak Song. The highest mean minimum is 74F at several locations. The extreme low temperature on record is 51F at Luang Prabang and Nape. (See Fig. 7i.)

3. Relative Humidity: Over most of Laos the humidity still remains high, resulting in conditions favorable for mildew, corrosion and decay of susceptible items. There is, however, some slight decrease in values from August to September as occasional intrusions of drier air enter the northern half of the country from mainland China. Mean values range from 86% at Luang Prabang to 80% at Xieng Khouang. The record low humidity is 30% at Luang Prabang. (See Fig. 8i.)

4. Precipitation and Thunderstorms: Although rainfall decreases from a midsummer maximum, September is a wet season month. Precipitation is generally light, but 2 to 4 days with rainfall in excess of 2 in. can be expected at exposed windward mountain locations.

The mean number of days with measurable precipitation ranges from 7 days at Tchepone, in a sheltered valley in the Annam Range to 25 days at Pak Song on the Boloven's Plateau. However, most of the country observes rainfall on 12 to 18 days. Mean monthly precipitation amounts over the northern part of Laos are generally less than 10 in. Much of the remainder of the country records mean values of 12 to 17 in. Regions with greater than 20 in. are: the region around Luang Prabang, the windward slopes of the Annam Range and the Boloven's Plateau.

Maximum monthly amounts range from 11 in. at Muong Nham, 120 mi southeast of Luang Prabang, to 65 in. at Attopeu, 70 mi east of Pakse. However, the maximum values at most locations in the north are less than 20 in., while those in the panhandle are 20 to 45 in. Minimum monthly rainfall amounts are 1 to 3 inches in the north and 6 to 10 inches in the panhandle. The highest monthly minimum is 11 in. at Attopeu. Maximum 24-hr precipitation values are 3 to 6 in. over most of the country, but windward slopes of the Annam Range have received one day values between 8 and 15 in.

Maximum thunderstorm activity, 10 to 15 thunderstorm days, occur along the border with Thailand, from Vientiane to Seno. Minimum activity, less than 5 thunderstorm days, occurs in the mountains north of Luang Prabang. Thunderstorms normally occur during the late afternoon and generally last only a few hours. September thunderstorm activity is caused by afternoon convection, orographic lifting and instability resulting from the passage of the ICZ. (See Figs. 9i, 10i and 11i.)

5. Cloudiness: Cloudiness begins to decrease significantly over northern Laos in September and to a lesser extent over the panhandle, although over

the entire country amounts remain high. Most cloudiness is caused by orographic lifting of warm, moist air as it approaches the Annam Range. Convective clouds form during the late morning and 2000 to 3000 ft ceilings are frequent in the afternoon. The least cloudiness occurs over the mountains north of Luang Prabang. Mean cloudiness north of 20°N is 60 to 80%, but over most of Laos it is between 75 and 85%. Widely scattered clouds (days with 3/10 or less cover) occur on 2 to 6 days throughout the country.

6. Visibility and Obstructions to Vision: With shower activity inhibiting smoke sources and reducing haze, daytime visibilities are relatively good. Morning visibilities of less than 2 mi occasionally occur in river fog, but these conditions seldom persist beyond 0900 LST. Fog can be expected on less than 5 days over most regions except in the valleys on the west slopes of the Annam Range. Maximum reported fog occurrence is 11 days at Tchepone in the mountains near the Vietnam border. Haze and smoke in the northern highlands frequently reduce visibilities to less than 5 mi for brief periods, and in more intense storms, to less than 1 mi. Visibilities greater than 12 mi are not common anywhere over Laos. (See Figs. 12i and 13i.)

7. Wind and Temperature Aloft: Heralding the approach of the northeast monsoon, northerly to northeasterly winds predominate north of 16°N latitude. South of 16°N latitude, prevailing directions are westerly. Mean speeds continue to decrease, but local surface winds, both directions and speeds, are influenced by local topography and can deviate significantly from mean winds. Most cases of strong gusty surface winds are associated with thunderstorm activity, but high winds can also be caused by channeling (Venturi effect). Channeling can be expected in mountain regions where valleys or passes face the prevailing wind.

North of 16°N latitude, northerly to northeasterly winds extend aloft to above 40,000 ft. South of 16°N a westerly flow predominates to about 15,000 ft. Above this altitude northeasterlies prevail.

During September the mean freezing level over Laos ranges from 16,500 ft in the north to 15,000 ft in the south. Upper air temperatures are close to -18C at 25,000 ft throughout the year.

8. Combined Ceiling and Visibility: Combined ceilings and visibilities are poorest during the early morning hours near sunrise with visibilities being the major restrictant. Ceilings of 5000 ft or more accompanied by visibilities of at least 5 mi ($\geq$5000/5) occur less than 10% of the time over the highest ridges along the eastern border regions. The best region at this time of day is along the Mekong Valley south of Seno and west of Vientiane. By mid-afternoon general improvement takes place, primarily in the regions of lowest frequency but there is little, if any, change in the overall pattern. Conditions along the Mekong are the best in the country. Improvement in visibility between morning and afternoon is generally offset by an increase in frequency of ceilings below 5000 ft after 1000 LST.

The frequency of $\geq$1000/2 1/2 is also at a minimum during the early morning hours and is less than 30% over the highest ridges of the Chaine Annamatique and in the mountains south of Xieng Khouang. Conditions are best over the Mekong Valley south of Boneng where $\geq$1000/2 1/2 occurs more than 90% of the time. Considerable improvement in those regions of lowest frequency takes place by mid-afternoon although no change in basic pattern occurs. By 1600 LST frequencies lower than 50% are confined primarily to the higher ridges of the Chaine Annamatique. Over much of the country the frequency of $\geq$1000/2 1/2 exceeds 90%. (See Figs. 14i, 15i, 16i and 17i.)

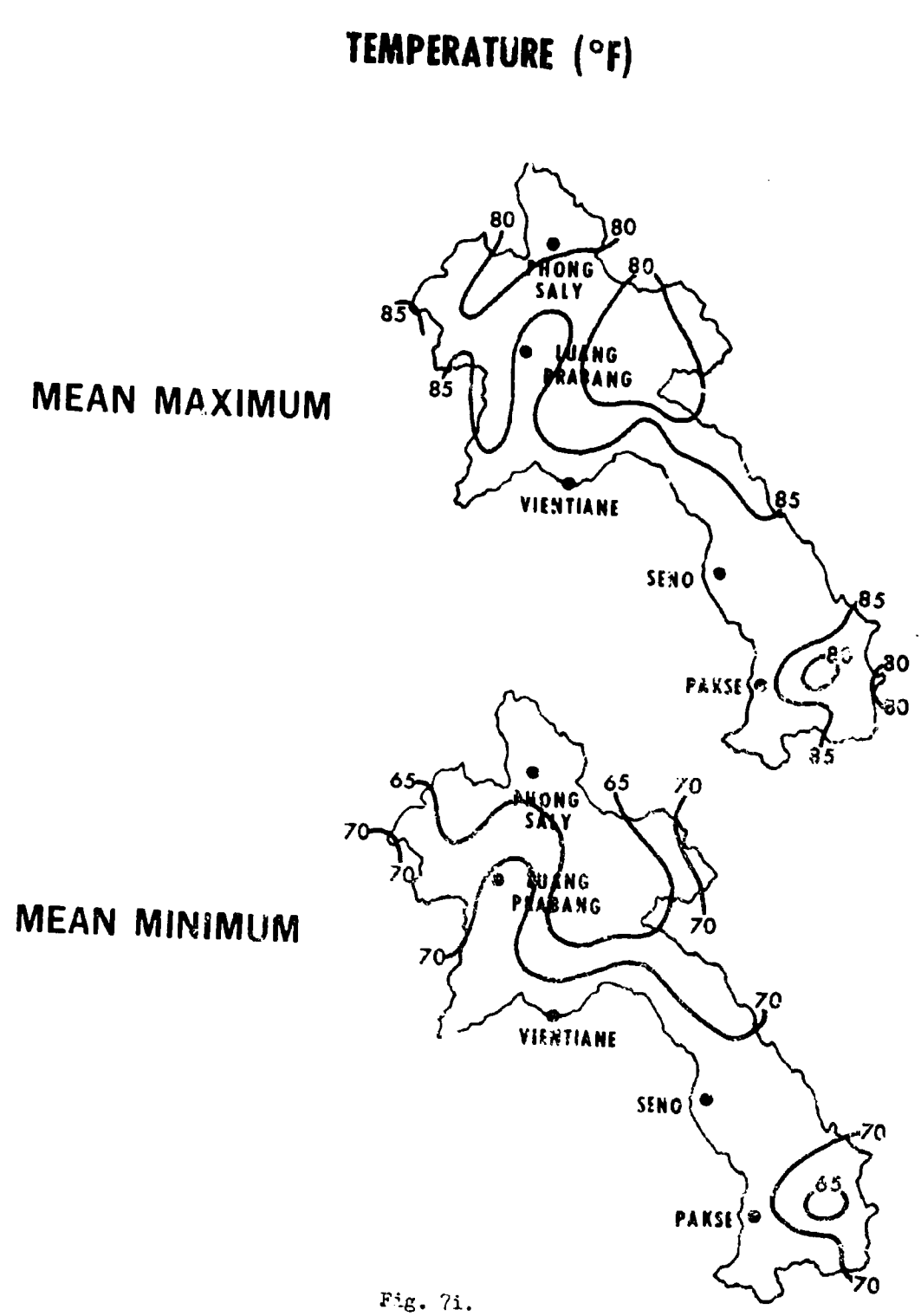

TEMPERATURE (°F)
MEAN MAXIMUM
MEAN MINIMUM
PHONG SALY
LUANG PRABANG
VIENTIANE
SENO
PAKSE
80
85
65
70
SEP

Fig. 7i.

MEAN RELATIVE HUMIDITY (%)

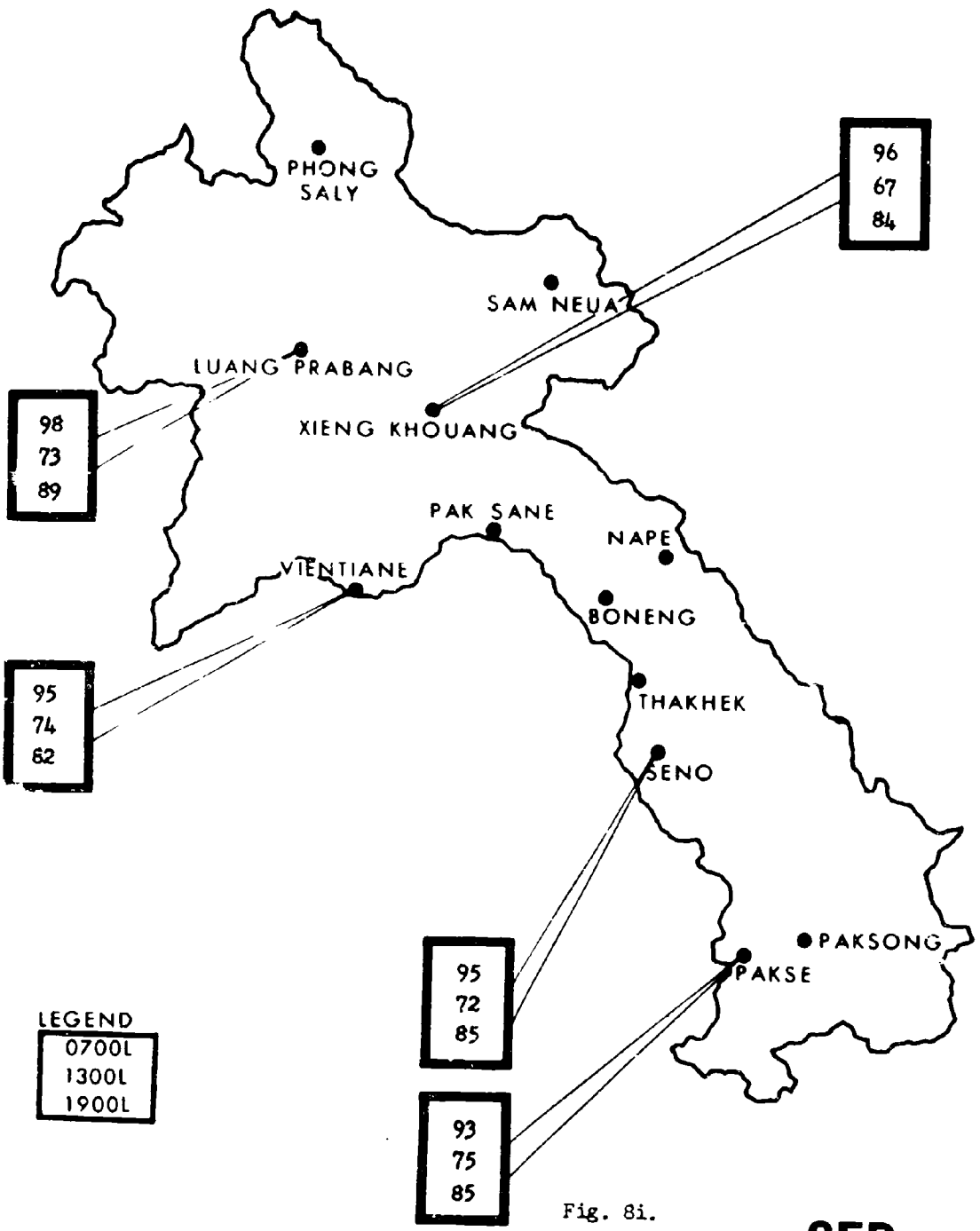


Fig. 8i.

SEP

MEAN NUMBER OF DAYS WITH PRECIPITATION

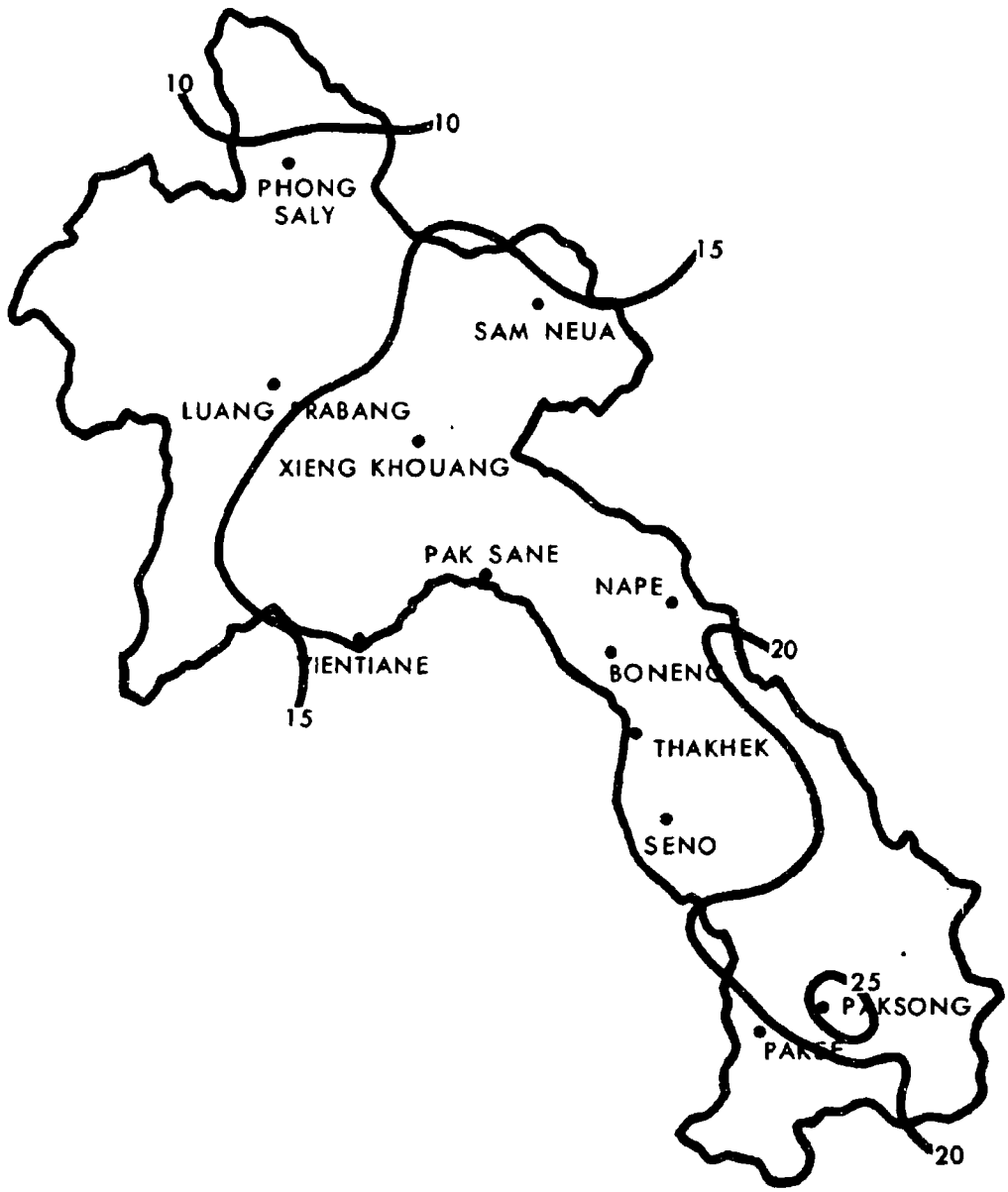


Fig. 9i.

SEP

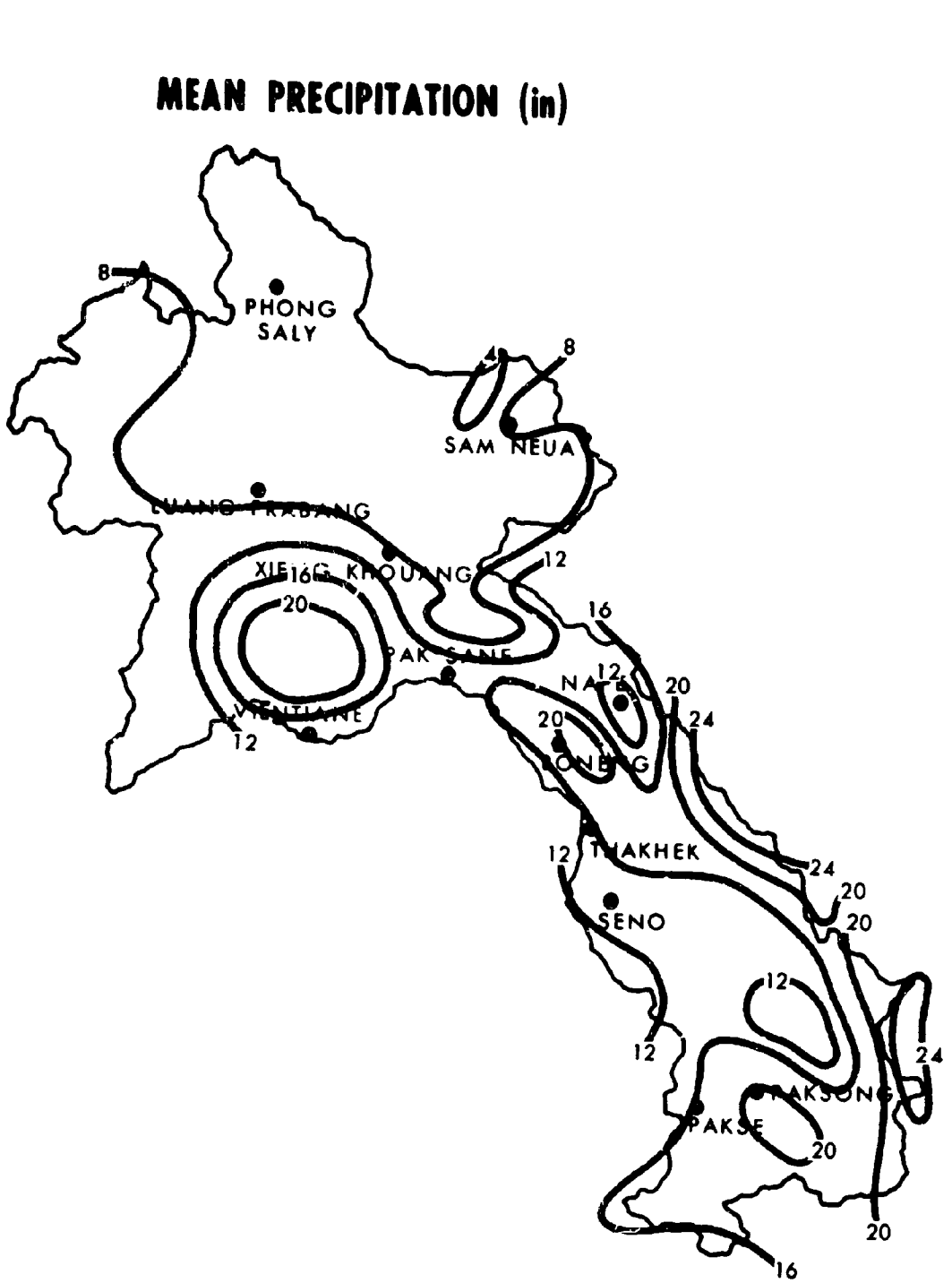

MEAN PRECIPITATION (in)
8
PHONG SALY
4
8
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
12
16
20
PAK SANE
NA
12
20
24
VIENTIANE
12
20
ONG
12
THAKHEK
24
20
20
SENO
12
12
24
PAKSE
20
20
16
SEP

Fig. 10i

PRECIPITATION and THUNDERSTORMS

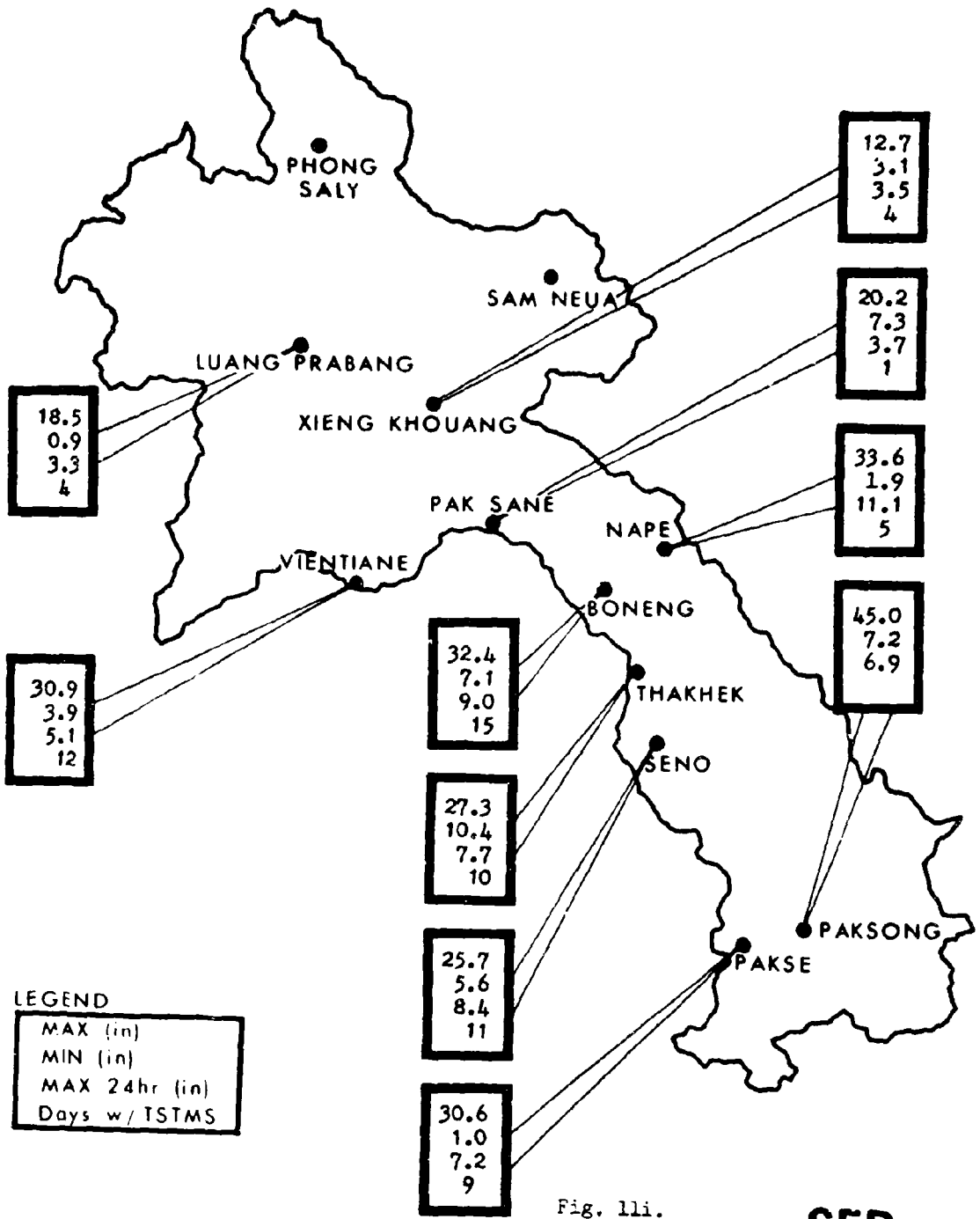
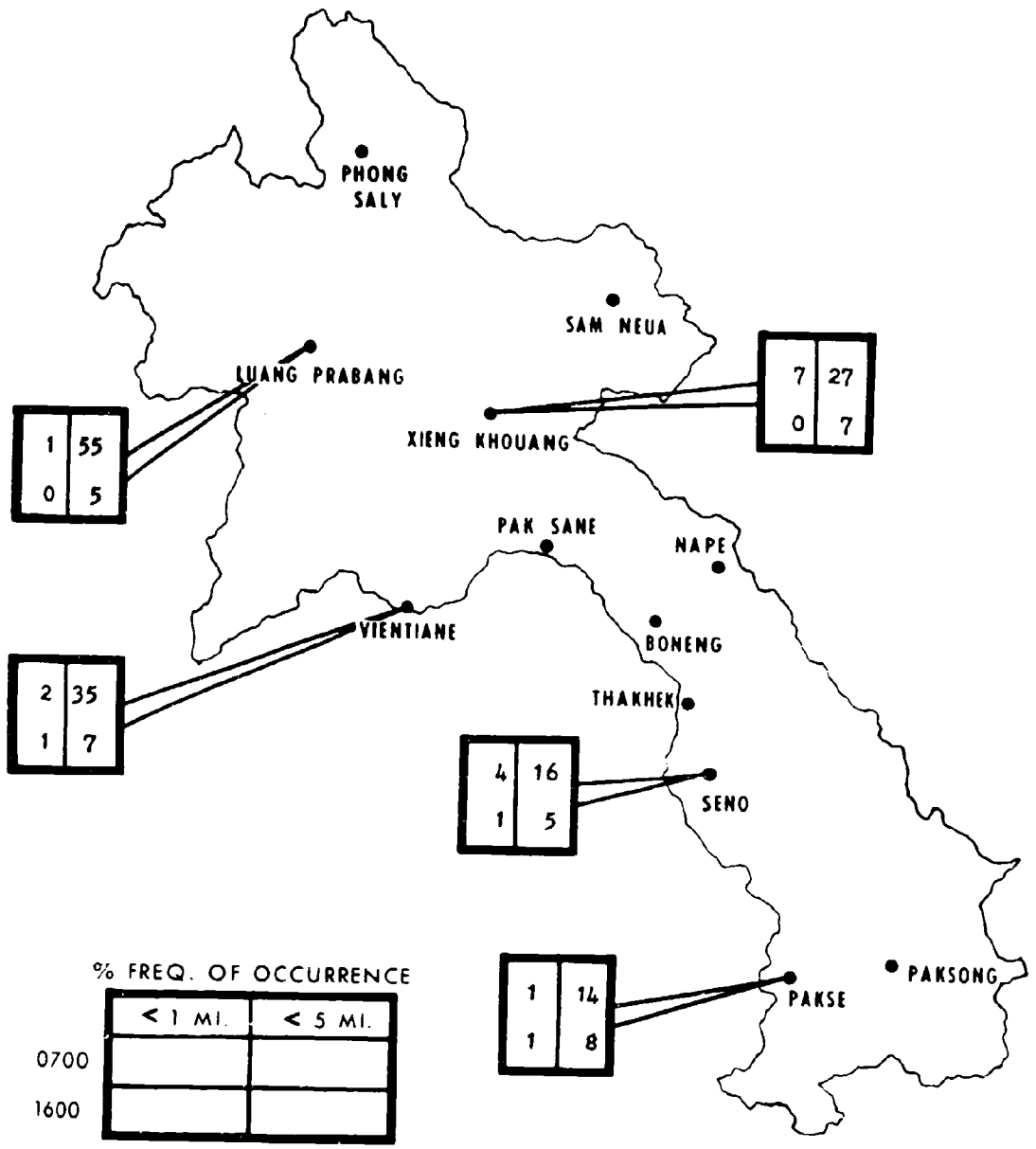


Fig. 11i.

SEP

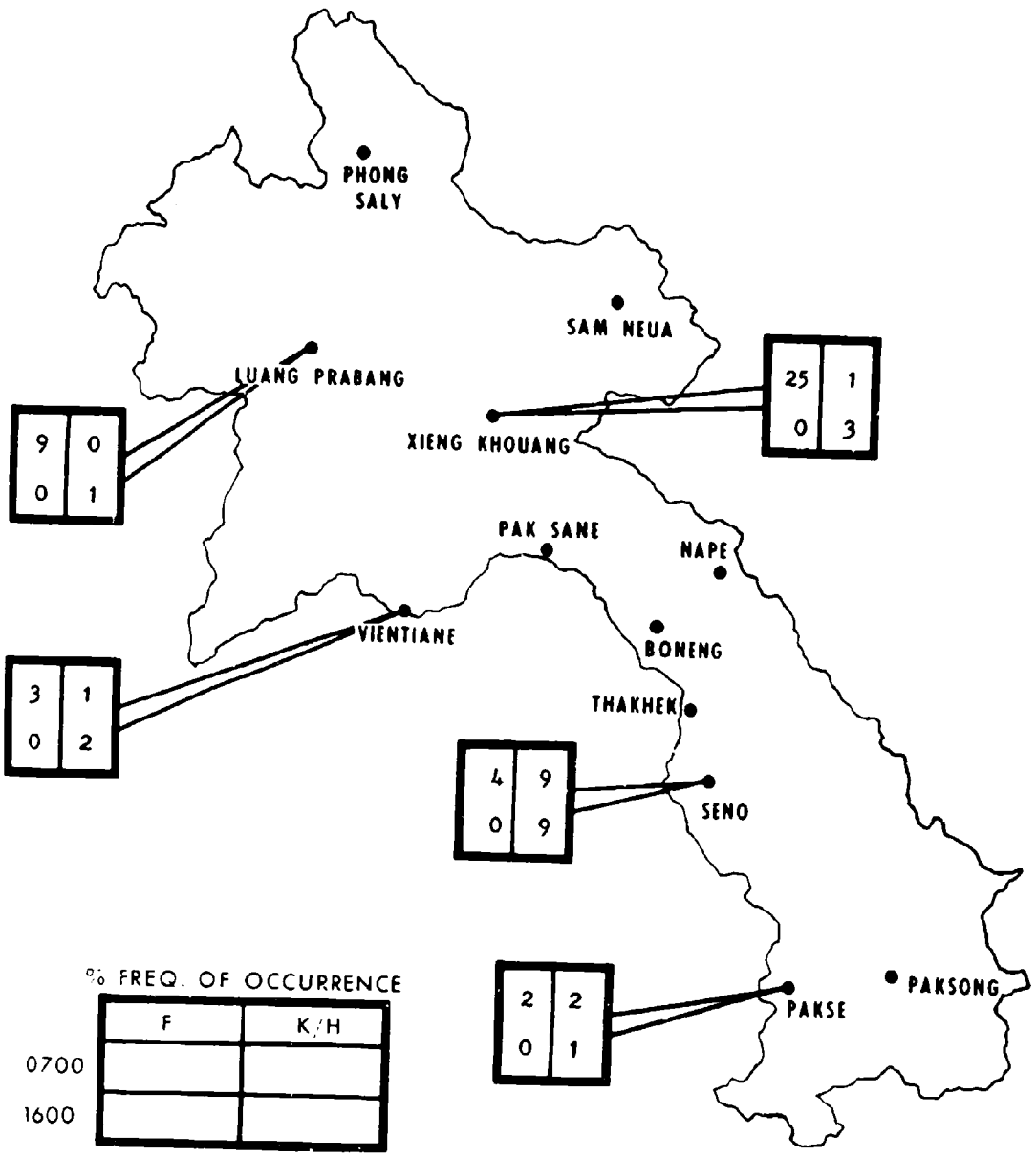
VISIBILITY



SEP

Fig. 12i.

FOG-SMOKE/HAZE



SEP

Fig. 13i.

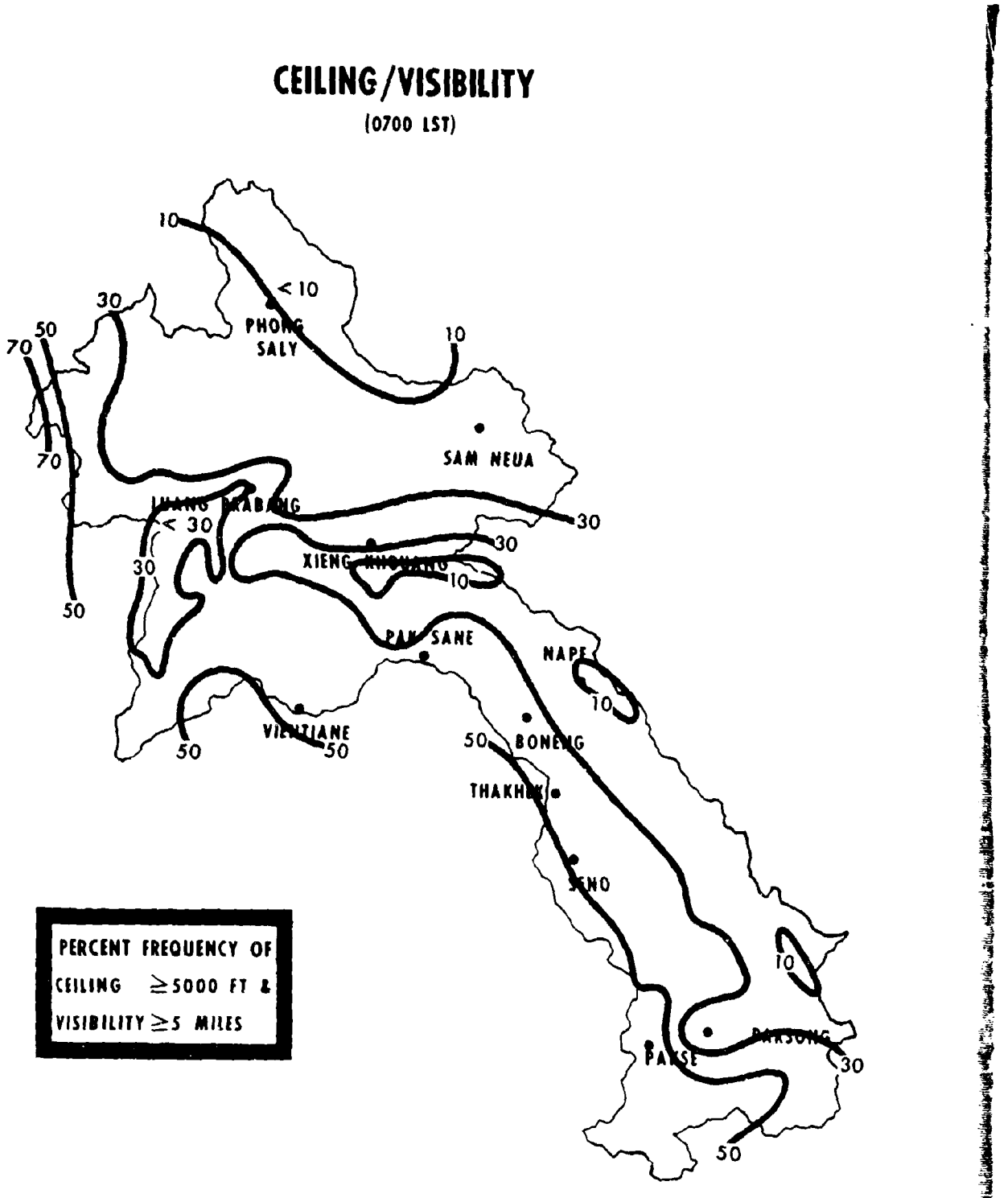

CEILING/VISIBILITY
(0700 LST)
10
< 10
30
50
70
PHONG SALY
10
SAM NEUA
70
30
< 30
30
30
10
50
PAK SANE
NAPE
10
50
50
50
BONENG
THAKHEK
SENO
10
30
50
PERCENT FREQUENCY OF
CEILING ≥5000 FT &
VISIBILITY ≥5 MILES

Fig. 14i

SEP

CEILING/VISIBILITY

(1600 LST)

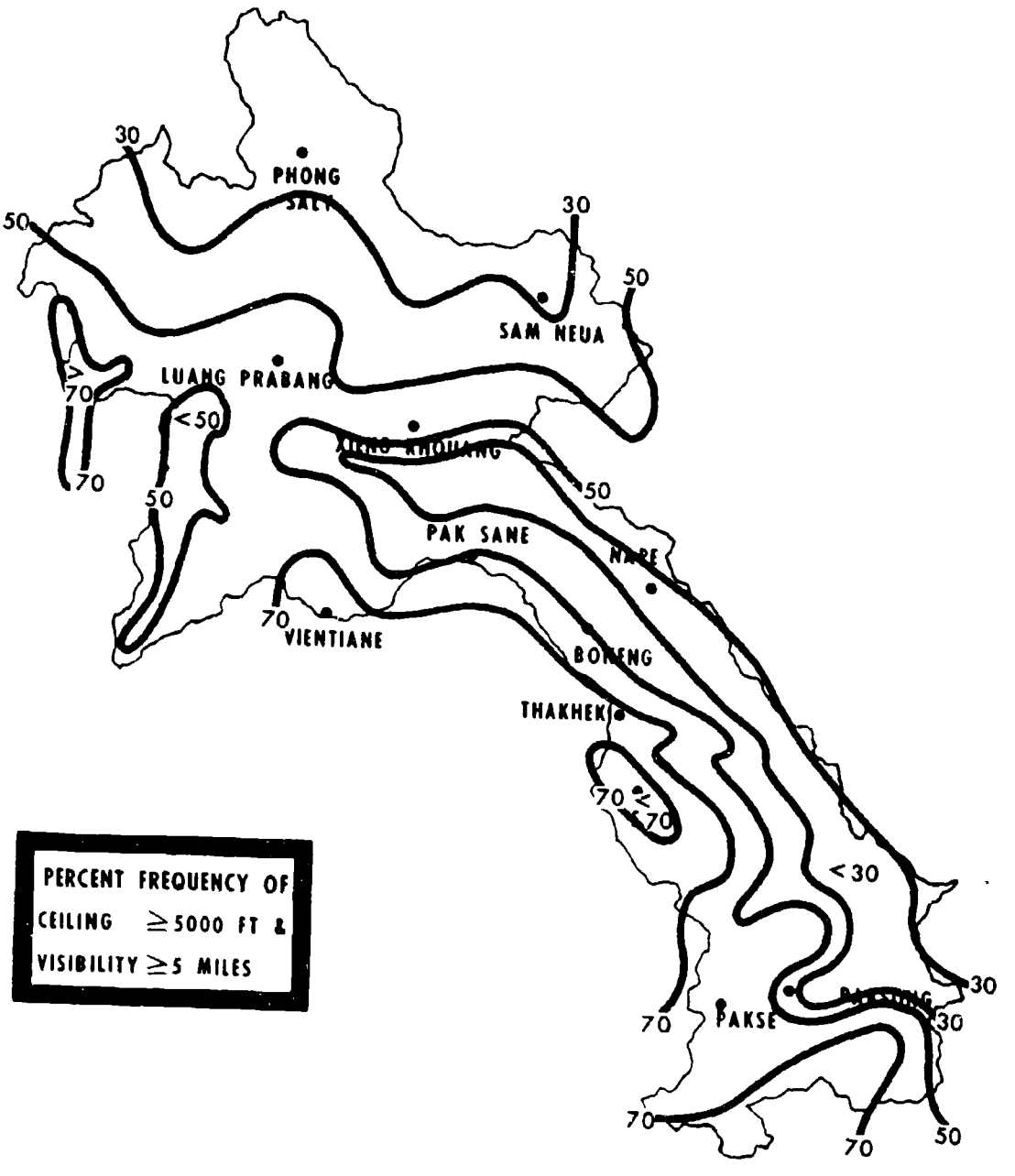


Fig. 15i

SEP

CEILING/VISIBILITY

(0700 LST)

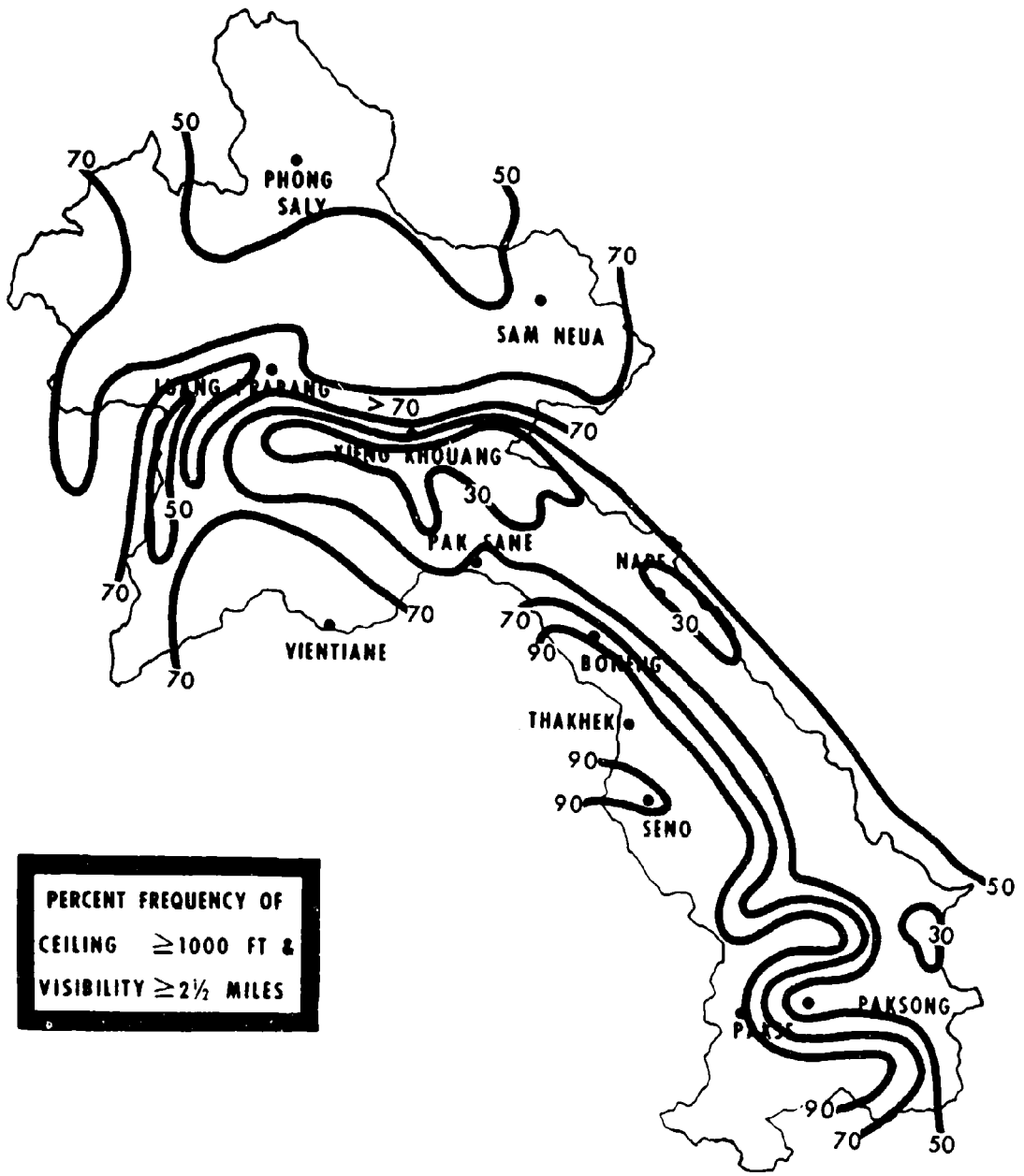


Fig. 16i

SEP

CEILING/VISIBILITY

(1600 LST)

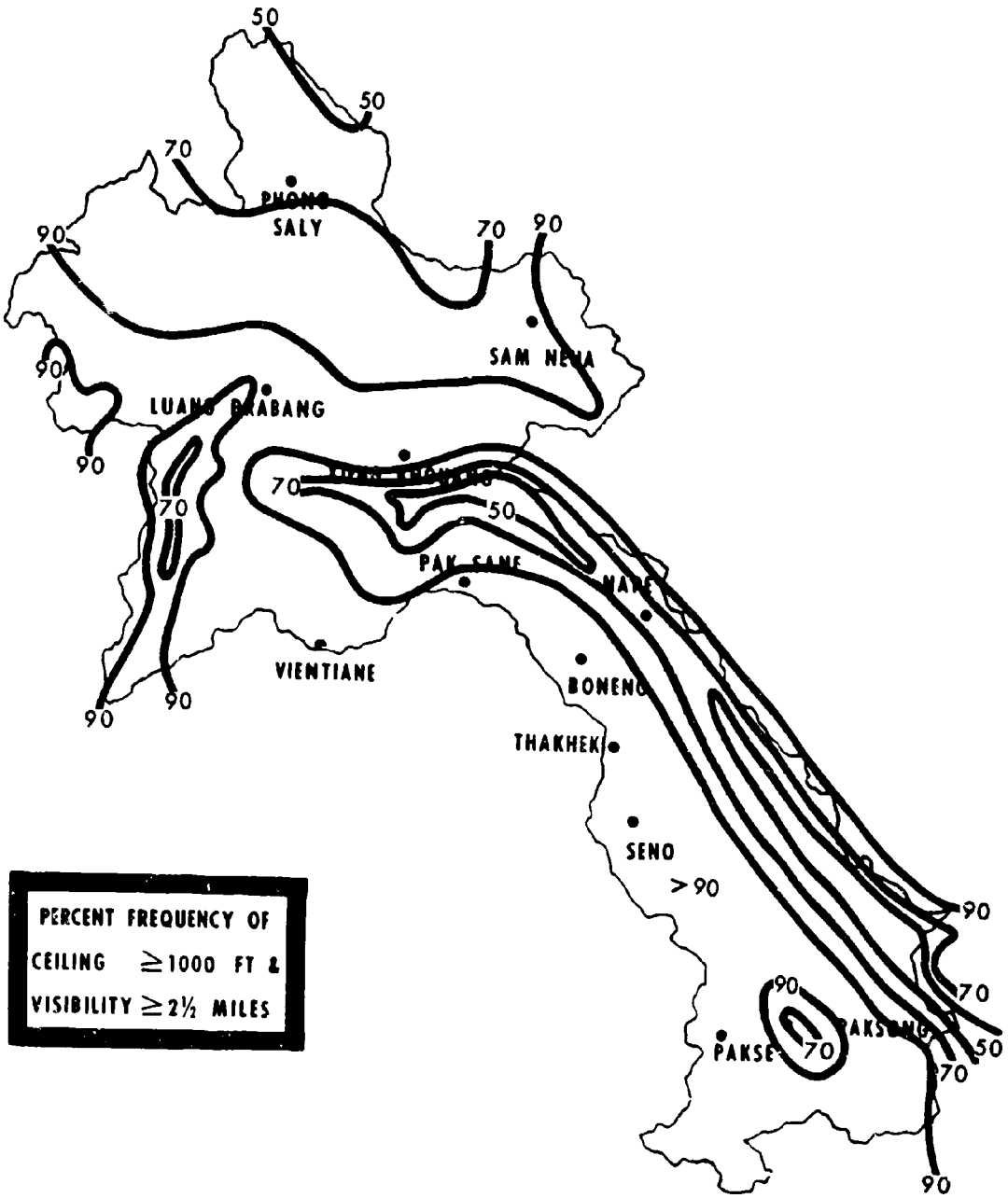


Fig. 171

SEP

SEPTEMBER SUNRISE, SUNSET AND TWILIGHT FOR VIENTIANE (17°59'N, 102°34E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0507	0533	0555	1824	1846	1912	-0.7	0.6
2	0508	0533	0555	1823	1846	1911	-0.7	0.6
3	0508	0534	0556	1823	1845	1910	-0.6	0.6
4	0508	0534	0556	1822	1844	1910	-0.6	0.5
5	0508	0534	0556	1821	1843	1909	-0.6	0.5
6	0508	0534	0556	1820	1842	1908	-0.6	0.5
7	0509	0534	0556	1819	1841	1907	-0.5	0.5
8	0509	0534	0556	1819	1840	1906	-0.5	0.4
9	0509	0535	0557	1818	1840	1905	-0.5	0.4
10	0509	0535	0557	1817	1839	1904	-0.4	0.4
11	0509	0535	0557	1816	1838	1903	-0.4	0.4
12	0510	0535	0557	1815	1837	1902	-0.4	0.3
13	0510	0535	0557	1814	1836	1902	-0.3	0.3
14	0510	0535	0557	1813	1835	1901	-0.3	0.3
15	0510	0536	0557	1813	1834	1900	-0.3	0.3
16	0510	0536	0558	1812	1834	1859	-0.2	0.2
17	0511	0536	0558	1811	1833	1858	-0.2	0.2
18	0511	0536	0558	1810	1832	1857	-0.2	0.2
19	0511	0536	0558	1809	1831	1856	-0.1	0.1
20	0511	0536	0558	1808	1830	1855	-0.1	0.1
21	0511	0537	0558	1807	1829	1854	-0.1	0.1
22	0511	0537	0558	1807	1828	1854	-0.1	0.0
23	0512	0537	0559	1806	1827	1853	0.0	0.0
24	0512	0537	0559	1805	1827	1852	0.0	0.0
25	0512	0537	0559	1804	1826	1851	0.0	0.0
26	0512	0537	0559	1803	1825	1850	0.0	-0.1
27	0512	0538	0559	1802	1824	1849	0.0	-0.1
28	0512	0538	0559	1802	1823	1848	0.1	-0.1
29	0513	0538	0600	1801	1822	1848	0.1	-0.2
30	0513	0538	0600	1800	1822	1847	0.1	-0.2

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 19i.

J. OCTOBER

1. Climatic Brief: In October the transition between the southwest monsoon and the northeast monsoon is complete and by the end of the month the northeast monsoon dominates all of Laos. In general, this is a month of improving weather conditions over most of the country as the trend of decreasing cloudiness, precipitation and thunderstorms started in September continues through October. During the month the Intertropical Convergence Zone (ICZ) moves completely through the country and continues on southward. The warm moist air of the southwest monsoon is replaced by the relatively cool, dry air of the northeast monsoon.

The airstreams of the northeast monsoon originate in the cold Siberian high pressure of the Northern Hemisphere. The air moves south to the South China Sea, merges with the warmer westerly flow from the Western Pacific, and arrives over the east coast of Southeast Asia with greatly modified temperatures and moisture content. Cloud amounts decrease over all of Southeast Asia, although there may be temporary increases due to the thunderstorm activity during the passage of the ICZ.

During the latter part of October, a regular diurnal sequence becomes apparent. A typical day begins with fair skies from midnight to 0400 LST, at which time low stratus forms over rivers and valleys while mountains and plateaus remain relatively clear. The stratus tends to break up as the morning progresses and mid-morning is usually the clearest time of the day. Subsequently, scattered cumulus clouds develop about 1000 LST as normal daytime heating continues; however, the number of days with afternoon and evening ceilings below 5,000 ft are relatively few in number except on the lee sides of mountains ranges.

Visibilities are generally good, but fog in northern valleys increases the occurrence of low visibility in this region. Afternoon visibilities are good except when restricted by precipitation.

During the first half of October precipitation is generally light. By mid-October the northeast monsoon precipitation regime prevails. Thus, in regions west of the Annam Range, most days are rain free, and most of the rain accumulation during the last 15 days of the month is caused by isolated thunderstorms. Temperatures are slightly cooler in October than during September. Maximums are in the mid-80's, and minimums are near 70F at most locations. Relative humidity decreases in all regions but still averages over 70%.

2. Temperatures: There is a noticeable decrease in mean temperatures, in October, over most of Laos. Although there is little change in afternoon maximums, from those in September, there is a decided drop in minimums. No temperature data are available for the region north of 20°N but available data from neighboring countries indicate that maximum temperatures in this area range from 75 to 82F. Maximums similar to this

should also be expected at higher elevations in the Annam Range and in the southern panhandle. Mean maximums over the remainder of the country are between 84 and 89F. The highest reported mean maximum is 89F at Luang Prabang and several other stations. The lowest mean maximum is 76F at Pak Song. The extreme high temperature on record is 101F at Luang Prabang.

Mean daily minimum temperatures range from 60F at higher elevations to around 70F along the Thailand border. The lowest reported mean minimum is 60F at several reporting stations and the highest is 72F at Pakse. The extreme low temperature on record is 44F at Xieng Khouang. (See Fig. 7j.)

3. Relative Humidity: Although relative humidity values decrease somewhat in October as intrusions of drier air enter the country from the north, the mean values are still relatively high. Mean values range from 72% at Xieng Khouang to 83% at Luang Prabang. The record low humidity is 21% at Boneng and Thakhek. The highest daily humidities occur during the early morning hours and after rainshowers; the lowest values occur during the afternoon. As with temperature, humidity can vary considerably over short distances. (See Fig. 8j.)

4. Precipitation and Thunderstorms: October is a transitional month between wet and dry seasons, and mean precipitations amounts decrease rapidly, although in the southern panhandle rainfall is still abundant. Precipitation is generally light, but 1 or 2 days with values in excess of 1 in. can be expected at most locations. Daily amounts in excess of 2 in. are rare. The majority of precipitation falls from afternoon and evening showers or thundershowers.

Precipitation is recorded on 10 to 16 days in the extreme south, 8 to 10 days on mountain slopes along the Vietnam border, and on 4 to 7 days over the remainder of the country. Mean rainfall amounts are 2 to 4 in. over the northern mountains and along the Thailand border, and 5 to 10 in. over the southern panhandle and Annam Range.

Reported maximum monthly amounts range from 2 in. at Muong Nham, 120 mi east of Luang Prabang to 27 in. at Pak Song. Maximum values at most locations in the north and along the Thailand border are 10 to 15 in., while those on exposed slopes on the panhandle are 16 to 35 in. Minimum October amounts over most of Laos are less than 1 in. The highest monthly minimum is 2 in. at Attopeu. Maximum 24-hr precipitation amounts range from 1 in. at Muong Nham to 10 in. at Pak Song.

Through October there is a rapid decr in thunderstorm activity over most of Laos. Five to 7 thunderstorm days are observed in the southern panhandle and 3 to 5 thunderstorm days are reported at locations along the Thailand border and over the remainder of the panhandle. Over the northern mountains thunderstorms can be expected on 1 day or less. (See Figs. 9j, 10j and 11j.)

5. Cloudiness: With the appearance of surges of the northeast monsoon in October cloudiness decreases somewhat over Laos. Cumulus clouds with bases 2,000 to 3,000 ft form after 1000 LST, but the occurrences of afternoon ceilings decrease sharply. October is the beginning of a seven-month period of good weather, particularly over the northern mountains. Around sunrise, 1000 ft stratus ceilings can form in major river valleys, but by 0900 LST they usually dissipate. Mean cloudiness varies from about 47% at Pak Sane to 65% at Pak Song. Widely scattered clouds (3/10 or less sky cover) occur on 6 to 10 days in northern mountains and windward slopes of the Annam Range and on 10 to 15 days over the remainder of the country.

6. Visibility and Obstructions to Vision: Early morning visibilities of 2 to 3 mi frequently occur in valley fog in the northern mountains, and in haze and smoke near heavily populated areas. Except in the north, where early morning fog increases, there is a general decrease in the occurrence of poor visibility over Laos. Haze and smoke also reduce visibilities in the northern highlands, particularly near sunrise. Fog can be expected on more than 5 days over the northern part of the country, and on windward slopes of the Annam Range. Elsewhere, fog is observed on 3 days or less. Maximum reported fog occurrence is 10 days at Luang Prabang. (See Figs. 12j and 13j.)

7. Wind and Temperatures Aloft: By the end of the month, northerly to northeasterly winds predominate over all of Laos. Mean speeds increase, but local surface winds, both directions and speeds, are influenced by local topography and can deviate significantly from mean speeds. Most cases of strong gusty surface winds are associated with thunderstorms, but high winds can also be caused by channeling (Venturi effect). Channeling can be expected in mountain regions where valleys or passes face the prevailing wind. The winds are compressed and packed, and the speeds increased, as they flow through the narrow confines. No data are available from Laos but at locations of this nature in Vietnam, wind speeds as high as 70 kt have been observed. Gusts in association with thunderstorms have been reported as high as 60 kt in both the lowlands and highlands of Vietnam and such should be expected over Laos under similar conditions.

Easterly winds extend aloft to about 10,000 ft north of 20°N latitude and to above 40,000 ft south of 17°N latitude. North of 17°N latitude the lower-level easterly flow is topped by westerly winds. Upper air temperatures are close to -18C at 25,000 ft throughout the year. During October the mean freezing level ranges from 16,000 ft in the north to 15,000 ft in the south.

8. Combined Ceiling and Visibility: Combined ceilings and visibilities are poorest during the early morning hours near sunrise with visibilities being the major restrictant. Ceilings of 5,000 ft or more accompanied by visibilities of at least 5 mi ($\geq$5000/5) occur less than 30% of the time over approximately two-thirds of the country at 0700 LST. The best region at this time of day is along the Mekong River Valley where frequencies are generally 50% or more and occasionally as high as 90%.

There is general improvement in these conditions between early morning and mid-afternoon although no change in basic pattern. By 1600 LST ≥5000/5 occurs as frequently as 70% or more of the time over most of the Mekong Valley. Along much of the Chaine Annamatique, percentages are still 30%.

The frequency of ≥1000/2 1/2 is also at a minimum during the early morning hours and is less than 30% at most of the higher elevations along the eastern border. Conditions are best over the Mekong Valley where ≥1000/2 1/2 occurs 70% or more of the time. Considerable improvement in those regions of lowest frequency takes place by mid-afternoon although no change in the basic pattern occurs. By 1600 LST frequencies lower than 50% are confined primarily to the higher ridges along the eastern border regions. Over much of the country the frequency of ≥1000/2 1/2 exceeds 90%. (See Figs. 14j, 15j, 16j and 17j.)

TEMPERATURE (°F)

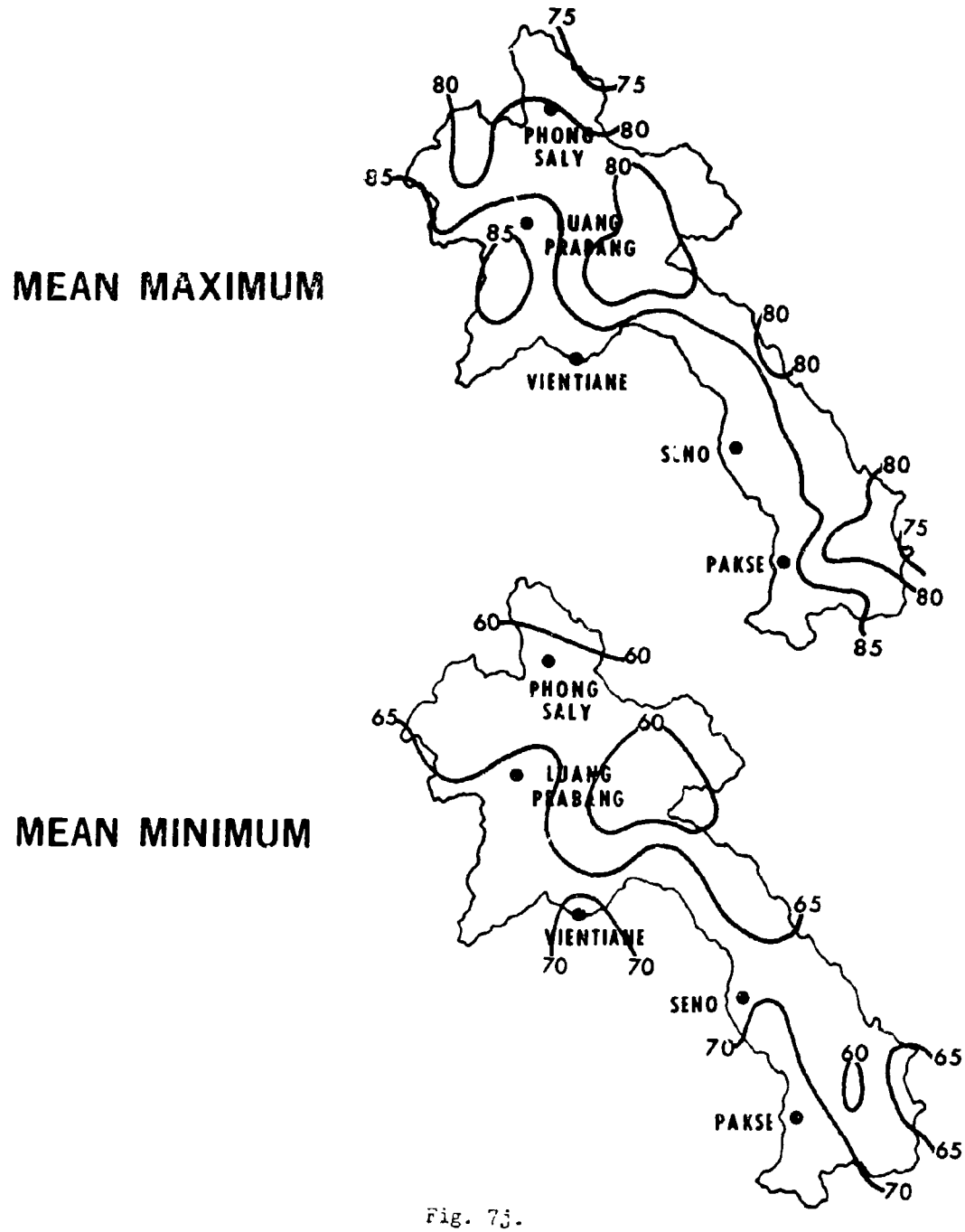


Fig. 73.

MEAN RELATIVE HUMIDITY (%)

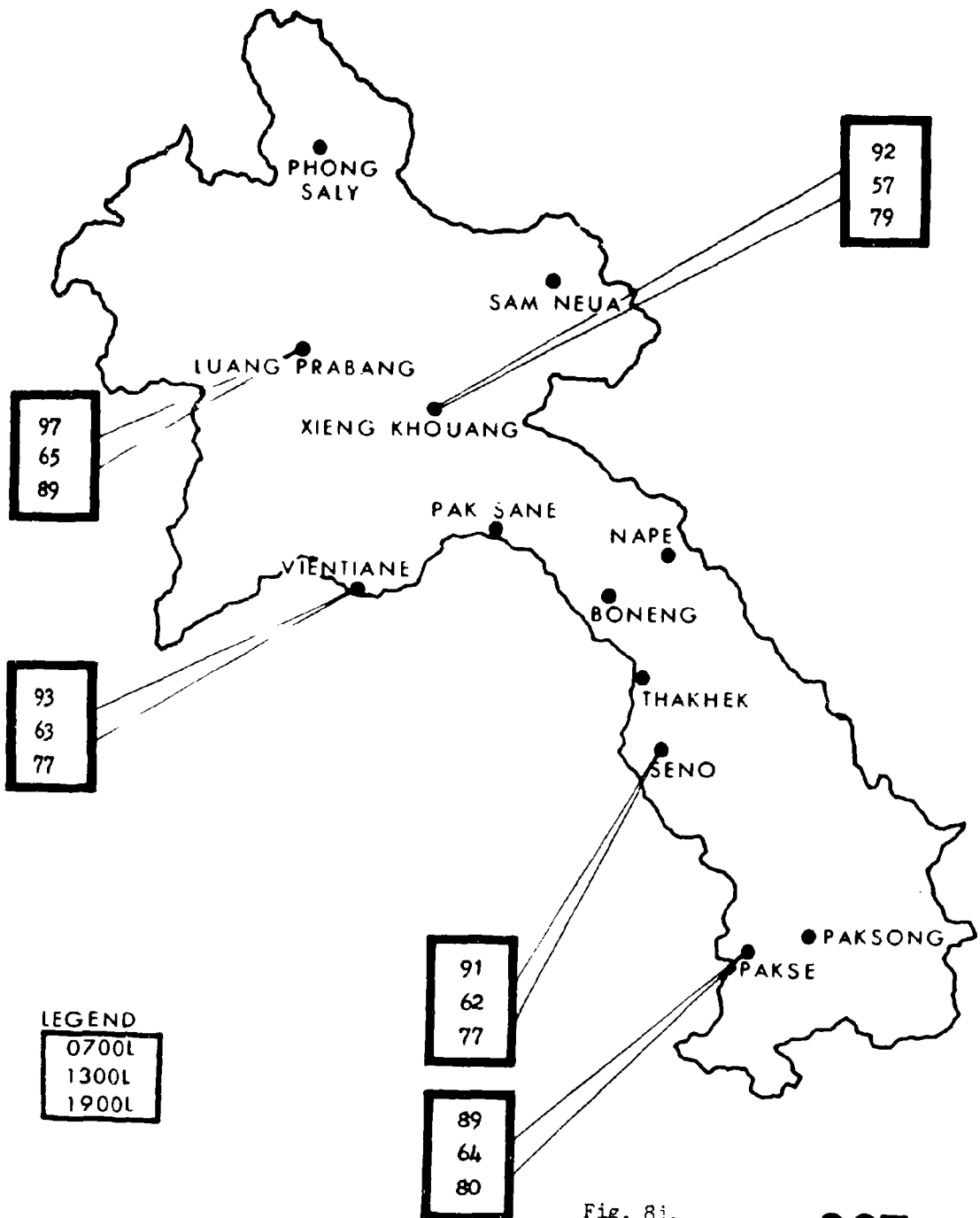


Fig. 8j.

OCT

MEAN NUMBER OF DAYS WITH PRECIPITATION

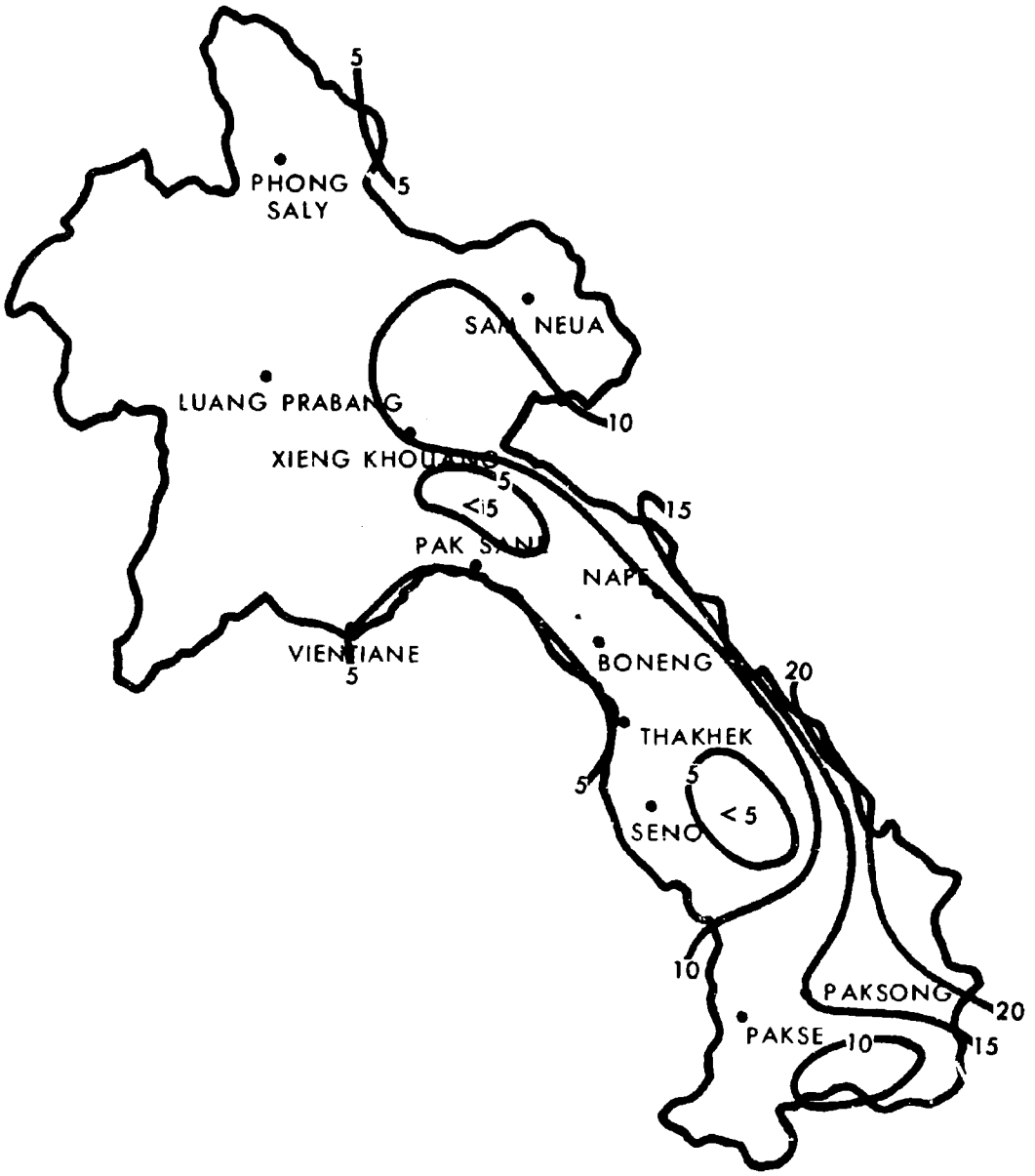


Fig. 93.

OCT

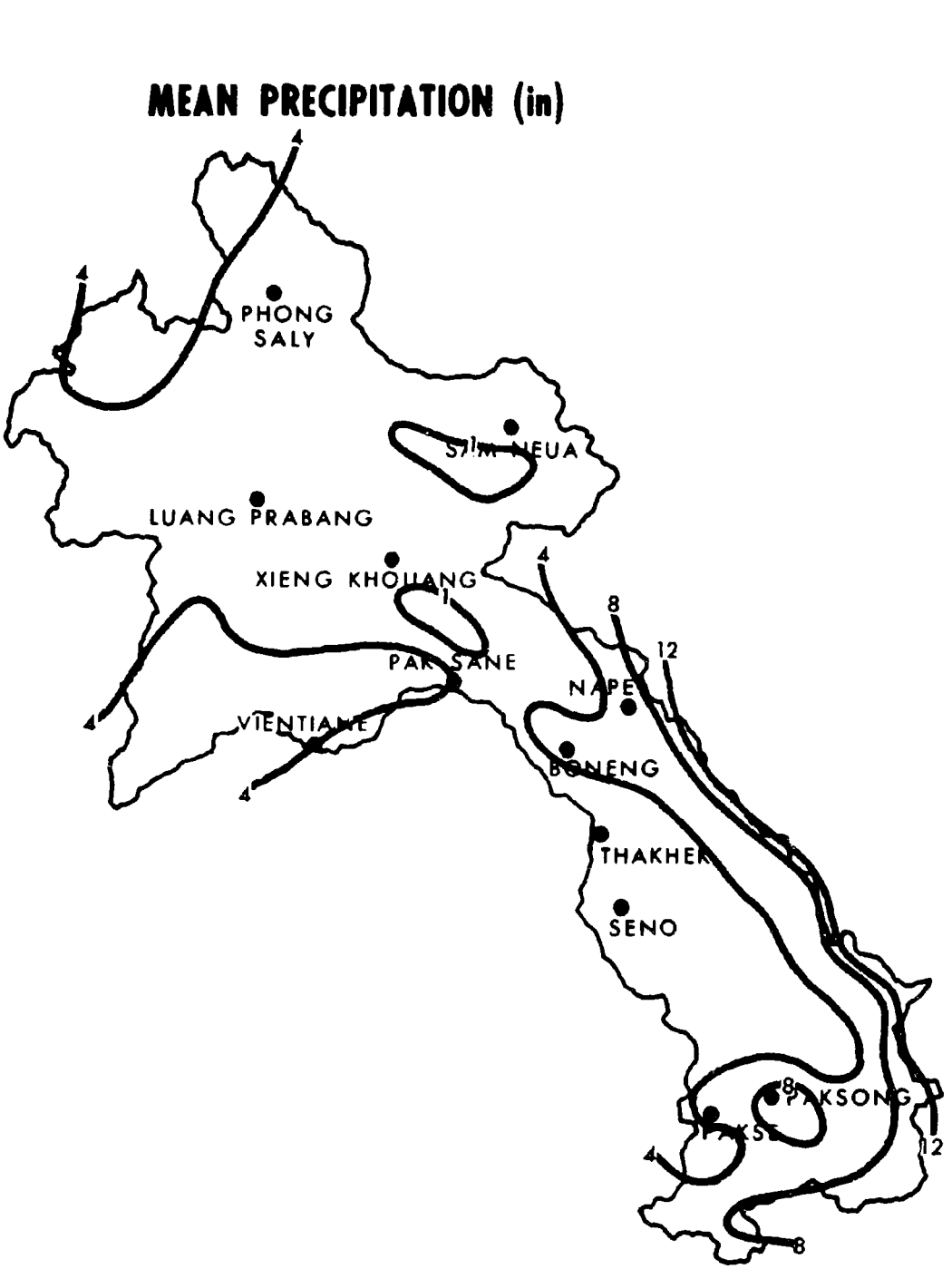

MEAN PRECIPITATION (in)
PHONG SALY
LUANG PRABANG
XIENG KHOUANG
PAKSANE
VIENTIANE
NAPE
BONENG
THAKHEK
SENO
PAKSONG
4
8
12
OCT

Fig. 10j

PRECIPITATION and THUNDERSTORMS

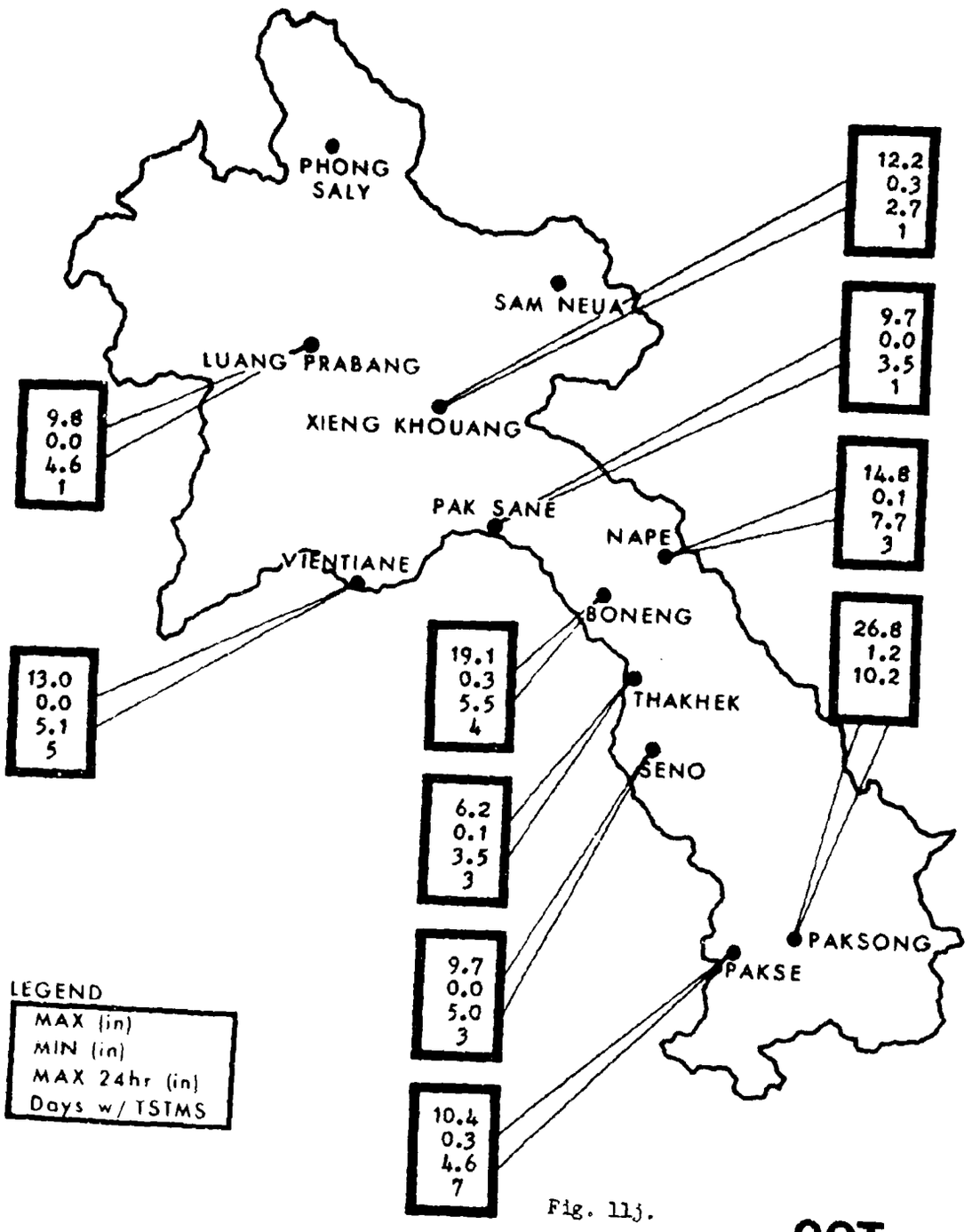
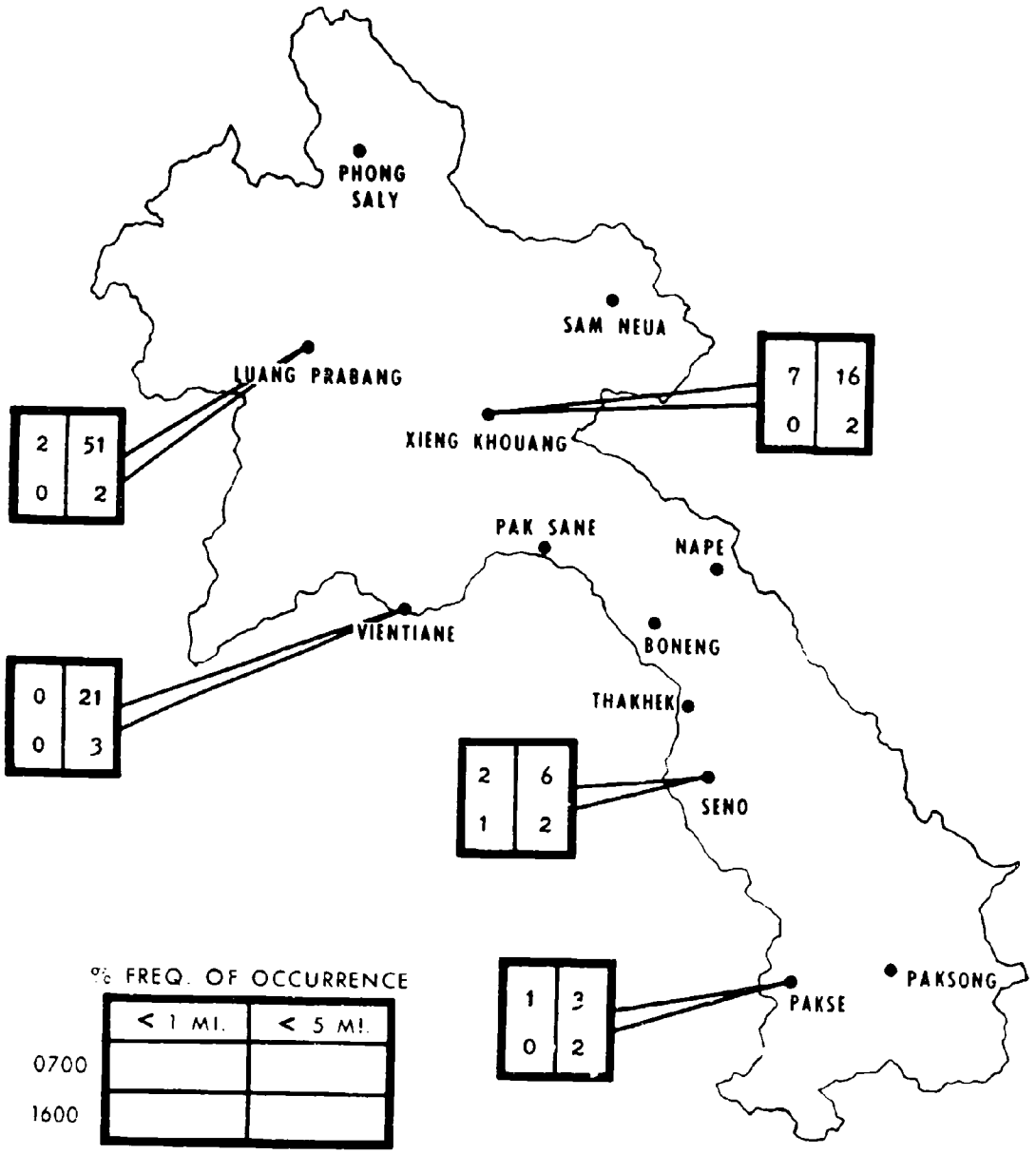


Fig. 11j.

OCT

VISIBILITY



OCT

Fig. 12j.

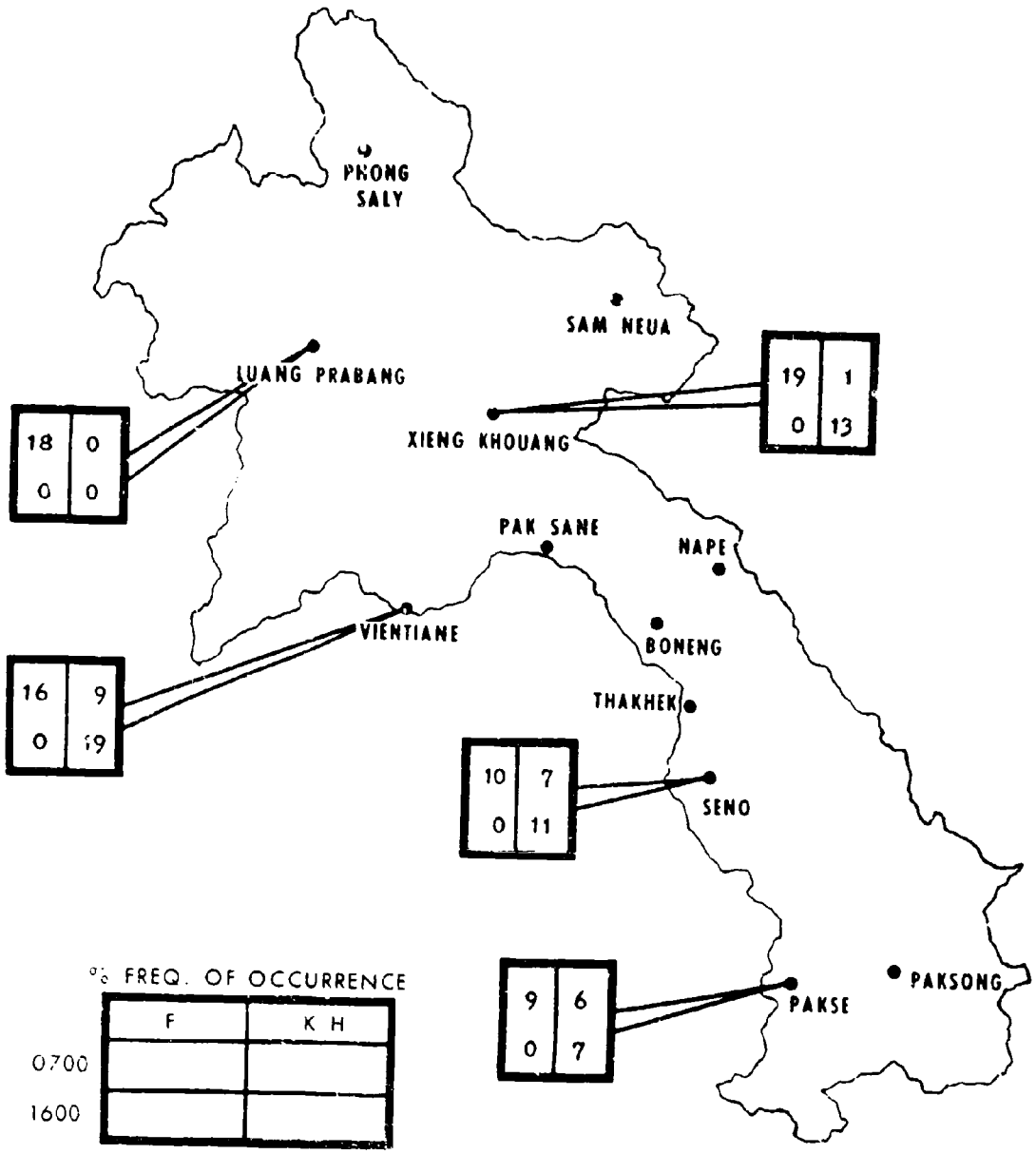

FOG-SMOKE/HAZE
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
PAKSE
18 0
0 0
19 1
0 13
16 9
0 19
10 7
0 11
9 6
0 7
% FREQ. OF OCCURRENCE
F
K H
0700
1600
OCT

Fig. 13j.

CEILING/VISIBILITY

(0700 LST)

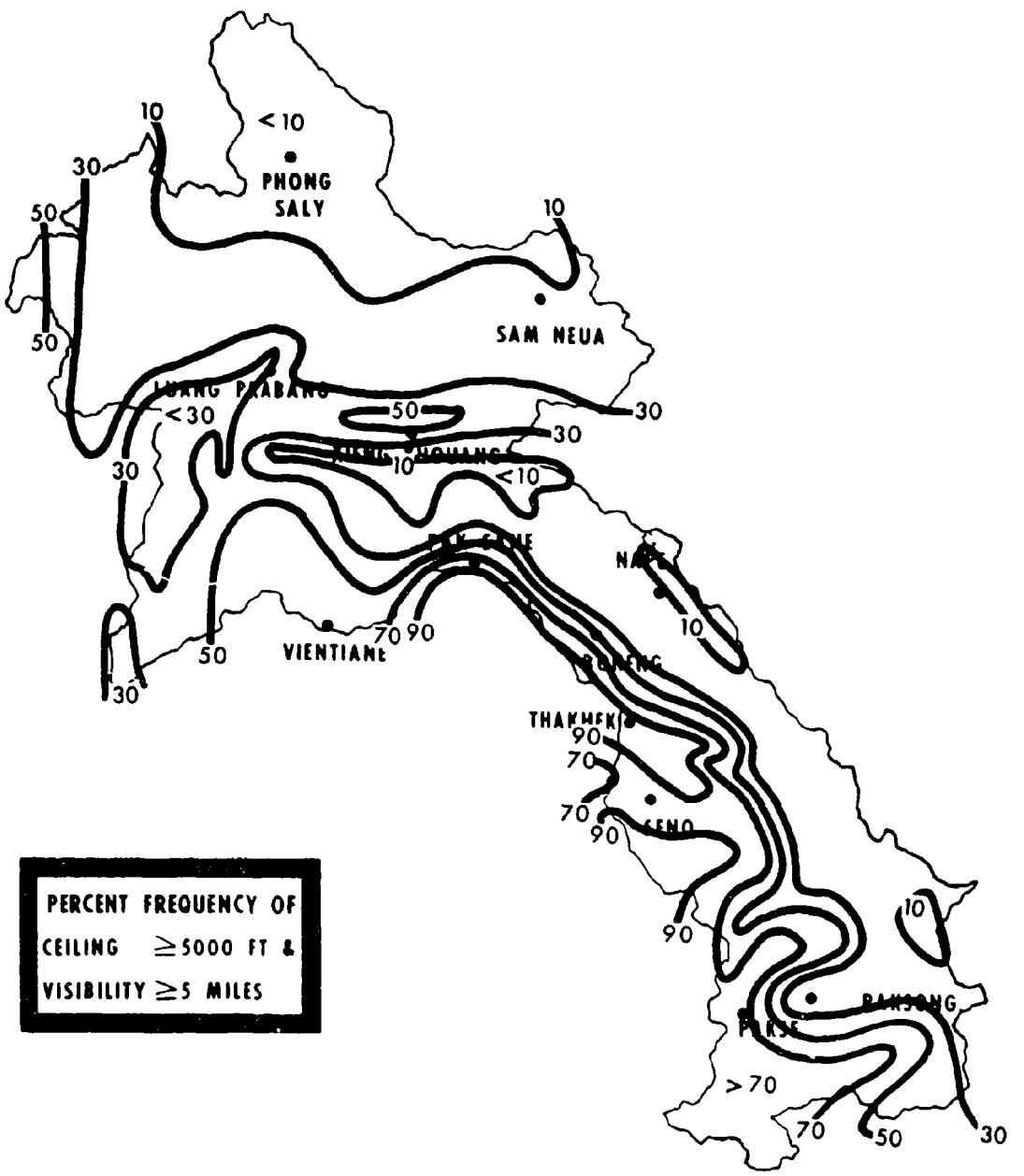
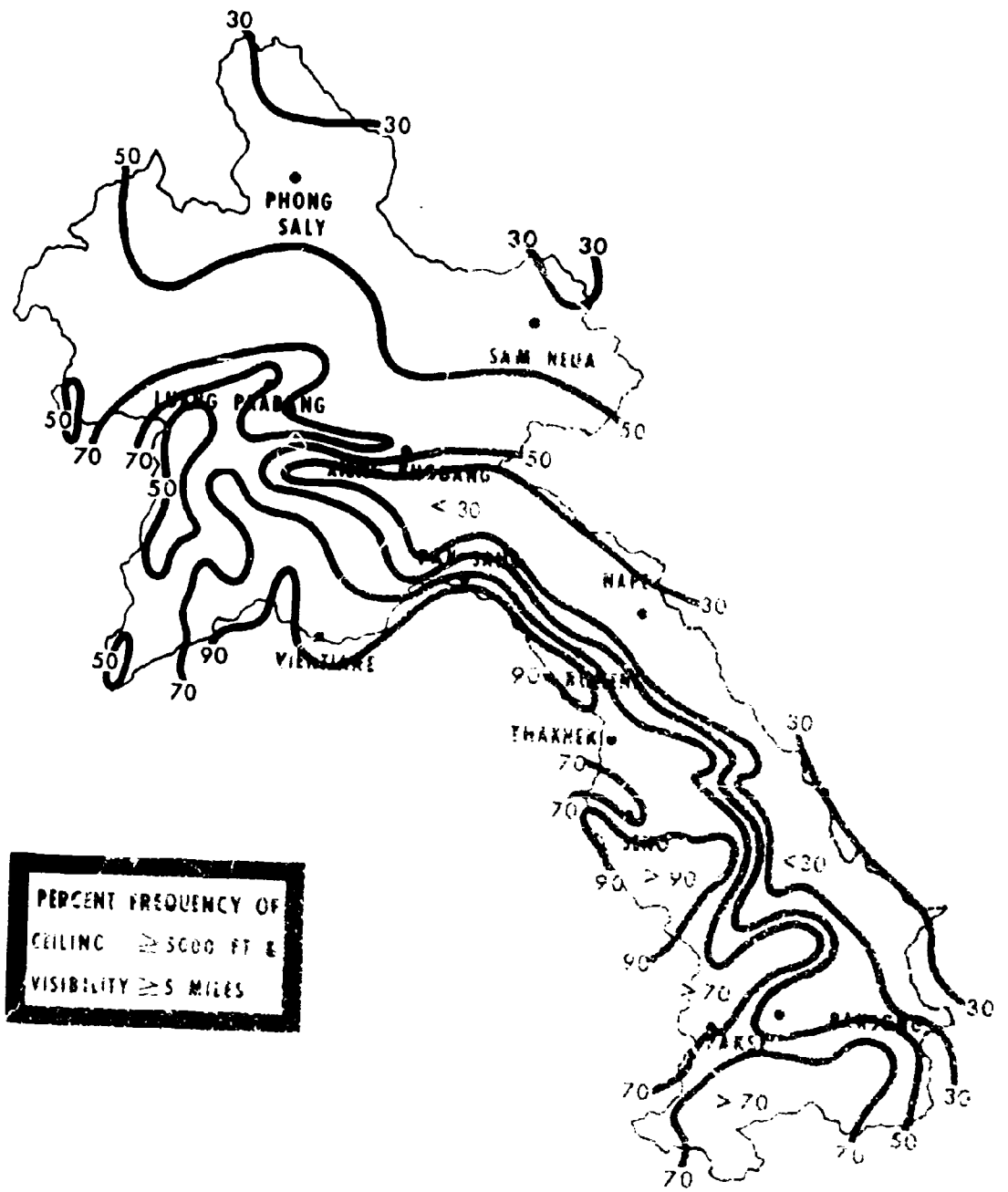


Fig. 1l.j

OCT

CEILING/VISIBILITY

(1600 LST)



OCT

CEILING/VISIBILITY

(0700 LST)

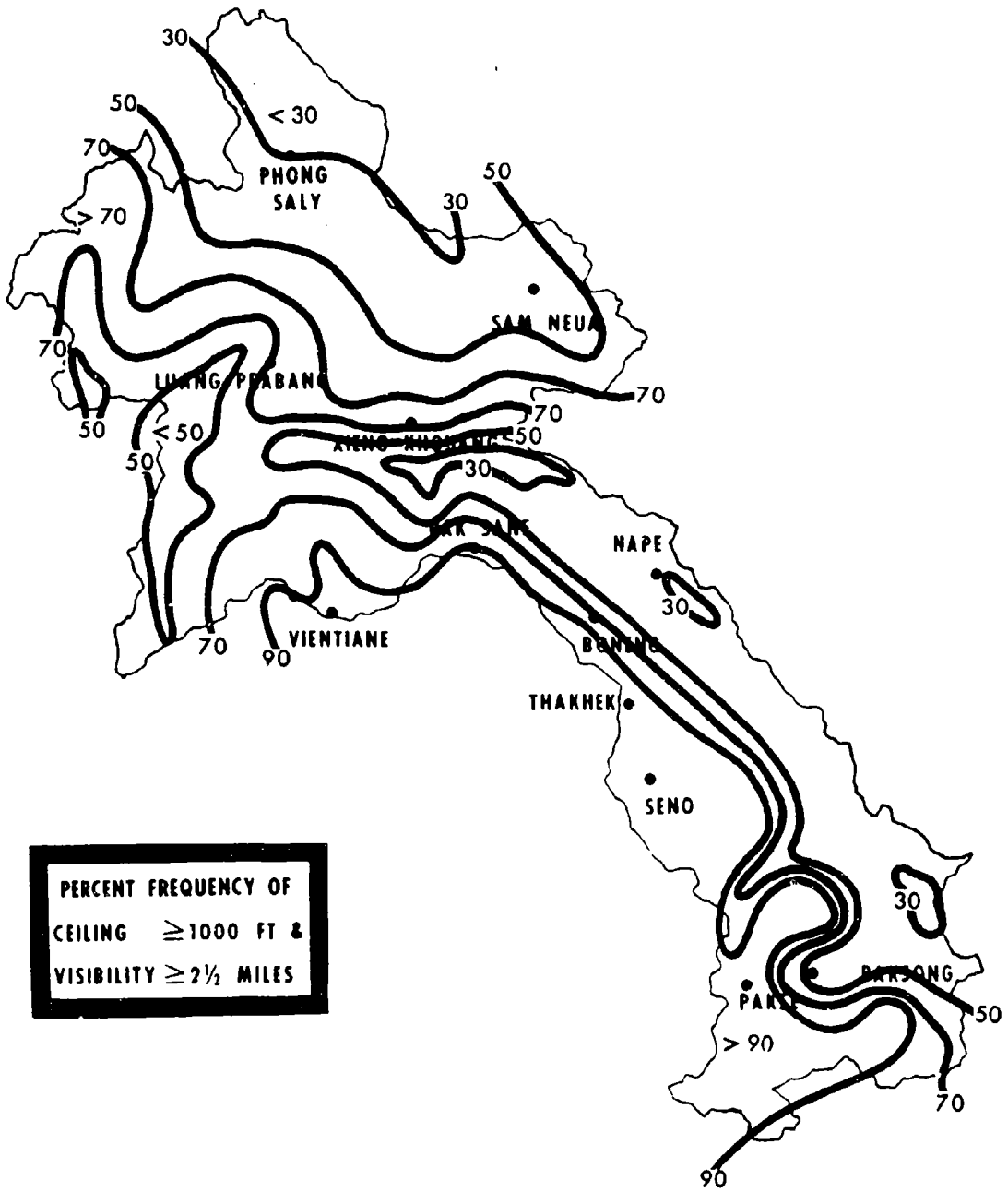


Fig. 16j

OCT

CEILING/VISIBILITY

(1600 LST)

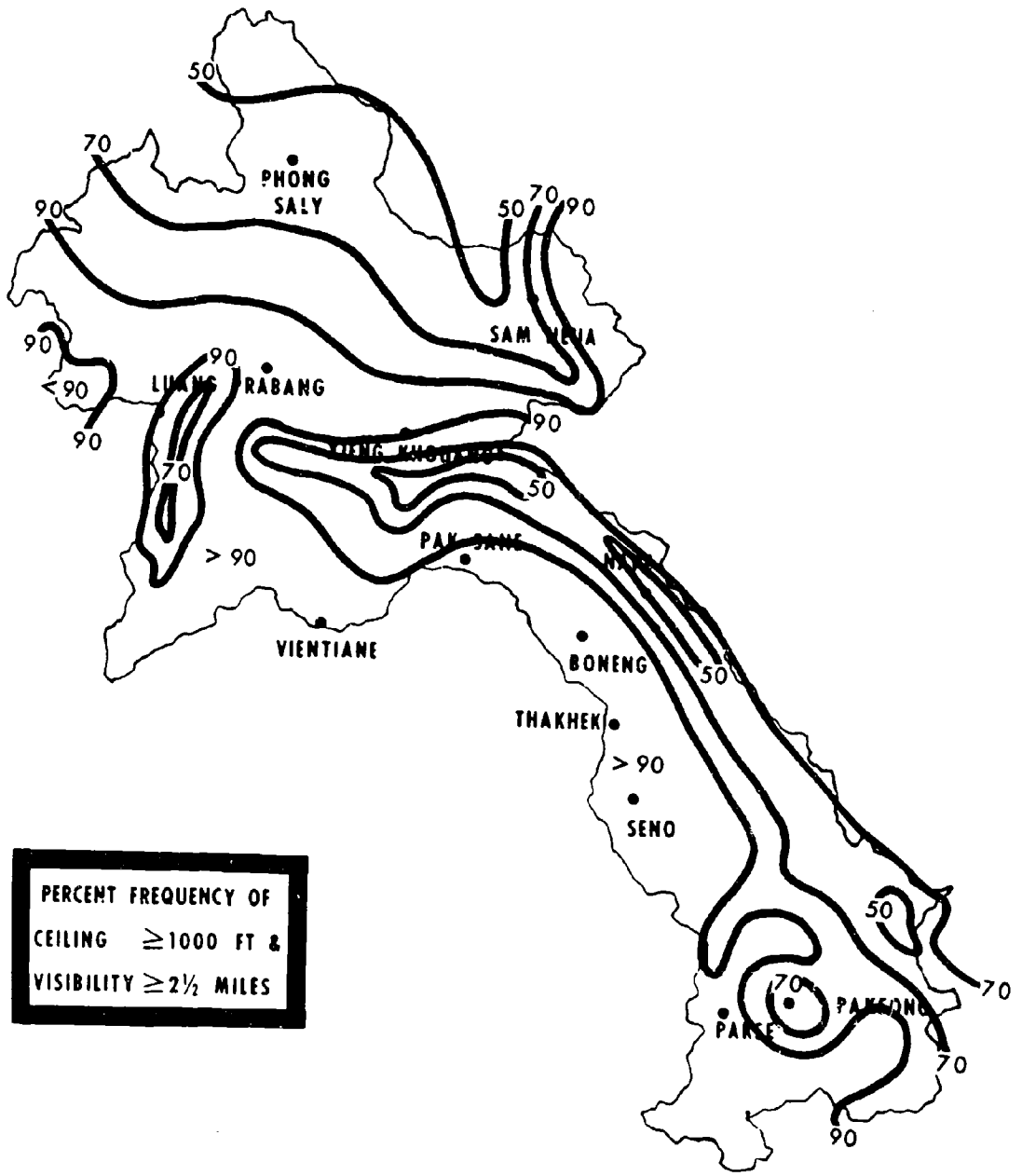


Fig. 17j

OCT

OCTOBER SUNRISE, SUNSET AND TWILIGHT FOR VIENTIANE (17°59'N, 102°34'E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0513	0538	0600	1759	1821	1846	0.2	-0.2
2	0513	0538	0600	1758	1820	1845	0.2	-0.2
3	0513	0539	0600	1757	1819	1844	0.2	-0.2
4	0514	0539	0601	1757	1818	1844	0.3	-0.3
5	0514	0539	0601	1756	1818	1843	0.3	-0.3
6	0514	0539	0601	1755	1817	1842	0.3	-0.3
7	0514	0539	0601	1754	1816	1841	0.4	-0.4
8	0514	0540	0601	1753	1815	1840	0.4	-0.4
9	0514	0540	0602	1753	1814	1840	0.4	-0.4
10	0515	0540	0602	1752	1814	1839	0.5	-0.5
11	0515	0540	0602	1751	1813	1838	0.5	-0.5
12	0515	0540	0602	1750	1812	1837	0.5	-0.5
13	0515	0541	0602	1750	1811	1837	0.6	-0.6
14	0515	0541	0603	1749	1811	1836	0.6	-0.6
15	0516	0541	0603	1748	1810	1835	0.6	-0.6
16	0516	0541	0603	1747	1809	1835	0.7	-0.7
17	0516	0542	0604	1747	1809	1834	0.7	-0.7
18	0516	0542	0604	1746	1808	1833	0.7	-0.7
19	0517	0542	0604	1745	1807	1833	0.8	-0.8
20	0517	0542	0604	1745	1807	1832	0.8	-0.8
21	0517	0543	0605	1744	1806	1832	0.8	-0.8
22	0517	0543	0605	1743	1806	1831	0.9	-0.9
23	0518	0543	0605	1743	1805	1830	0.9	-0.9
24	0518	0544	0606	1742	1804	1830	0.9	-0.9
25	0518	0544	0606	1742	1804	1829	1.0	-1.0
26	0519	0544	0606	1741	1803	1829	1.0	-1.0
27	0519	0544	0607	1740	1803	1828	1.0	-1.0
28	0519	0545	0607	1740	1802	1828	1.1	-1.1
29	0519	0545	0607	1739	1802	1827	1.1	-1.1
30	0520	0545	0608	1739	1801	1827	1.1	-1.1
31	0520	0546	0608	1738	1801	1827	1.2	-1.2

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 18j.

K. NOVEMBER

1. Climatic Brief: By November, all of Southeast Asia is under the influence of the northeast monsoon. The airstreams of the northeast monsoon originate in the cold Siberian and warm North Pacific high pressure cells. As the cold dry air from the Siberian high flows south it is gradually heated by contact with the warmer China coast and the waters of the South China Sea. This air then merges with the warm air from the Western Pacific and arrives over Southeast Asia much warmer and more moist than when it left the continent. Compared with the southwest monsoon, the northeast monsoon is relatively cool and dry.

Most cloudiness and precipitation occur on the windward slopes of the Annam Range and along the east coasts of North Vietnam and South Vietnam. By the time the flow crosses the mountain range and enters Laos, most of the cloud and precipitation producing moisture has been removed, and Laos enjoys relatively clear skies and little precipitation during November.

A normal diurnal sequence begins with fair skies from 2300 to 0400 LST, at which time stratus and fog form over rivers and valleys at most locations, while mountain and plateau areas remain relatively clear. The stratus and fog tend to break up as the morning progresses, but scattered cumulus clouds develop as normal daytime heating continues. These clouds seldom form ceilings, and afternoons or evenings with broken or overcast conditions are relatively few.

Visibilities are generally good, however, fog in northern valleys increases the occurrence of low visibility in these regions. Afternoon visibilities are good except when restricted by precipitation.

Mean precipitation amounts decrease greatly from October to November. Over almost all of Laos mean precipitation amounts average ½ in. or less on anywhere from 1 to 4 days. Thunderstorm activity decreases and averages only 1 day per month at most locations.

A cooling trend, most noticeable in the minimum temperatures, takes place over all of Laos. Mean temperatures range from 60F in the north to about 80F in the southern part of the panhandle. Relative humidities average 70 to 80%.

2. Temperatures: With the onset of the northeast monsoon, temperatures decrease over all of Laos. North of 20°N, available data from neighboring countries indicate that maximum temperatures range from near 70 to 80F. Maximums between 75 and 80F also occur at higher elevations in the Annam Range and in the southern panhandle. Mean maximums over the remainder of the country are between 83 and 88F. The highest reported mean maximum is 88F at Pakse and the lowest is 74F at Xieng Khouang. The extreme high temperature is 99F at Boneng.

Mean daily minimum temperatures range from 55 to 65F over most of the country. The lowest reported mean minimum is 55F at Xieng Khouang and the highest is 69F at Pakse. The extreme low temperature is 40F at Xieng Khouang. (See Fig. 7k.)

3. Relative Humidity: Although high in absolute value, relative humidities continue to decrease from their summertime maximum. Mean values range from 69% at Pakse and Xieng Khouang to 81% at Luang Prabang. The record low humidity is 23% at Pakse. The highest daily humidities occur during the early morning hours and after rainshowers; the lowest values occur during the afternoon. (See Fig. 8k.)

4. Precipitation and Thunderstorms: November is a dry season month and mean rainfall amounts decrease significantly. Precipitation is generally light and daily amounts in excess of 1 in. are rare. Most of Laos can expect precipitation on 1 to 5 days during November. Maximum reported days with rainfall occurrence is 9 at Pak Song. Mean precipitation values are 1 to 5 in. at most locations; however, on windward slopes of the Annam Range amounts greater than 10 in. should be expected. Mean amounts are less than 1 in. along the Thailand border. Reported maximum monthly values in the north range from 1 in. at Thakhek to 12 in. at Phong Saly, but maximum amounts at most locations are 5 to 8 in. Maximum values on exposed slopes in the panhandle are above 20 in. Minimum November amounts over most of Laos are zero. The highest monthly minimum on record is 1 in. at Pak Song. Maximum 24-hr precipitation amounts range from 0.5 in. at Nape to 4 in. at several widely separated reporting locations.

With the advent of the northeast monsoon, thunderstorm activity is greatly diminished over most of the area. Thunderstorms are rare over Laos. In the southern panhandle they occur on an average of 3 days a month but over the remainder of the country the mean is 1 day or less. Thunderstorms generally occur in the afternoon, last no more than a few hours and are seldom violent although strong surface winds may occur. (See Figs 9k, 10k and 11k.)

5. Cloudiness: With northeasterly monsoonal winds dominating the country during November, cloudiness decreases over most regions. Based on neighboring country data there is some slight increase in cloudiness over parts of the northern mountains. Cumulus clouds, with bases 2,000 to 3,000 ft, form after 1000 LST, but the occurrences of afternoon ceilings decrease sharply. Around sunrise, 1,000 ft stratus ceilings can form in major river valleys, but by 0900 LST they usually dissipate. Mean cloudiness varies from 33% at Thakhek, to 59% at Xieng Khouang. Days with scattered clouds occur on 4 to 6 days in northern mountains and on windward slopes of the Annam Range, and on 12 to 18 days over the remainder of the country.

6. Visibility and Obstructions to Vision: Except over the northern half of the country where there is an increase in fog frequency, there is a general decrease in the occurrence of poor visibility over Laos. In

the northern half of the country visibilities of less than 2 mi frequently occur in river valley fog. Radiation fog is most likely in river valleys, and most prevalent and persistent in deep, steep walled valleys. Fog, normally light and nonpersistent, forms during predawn hours and dissipates rapidly after sunrise, but in deeper valleys it may form earlier and persist through the morning. Fog can be expected on more than 5 days in the north and on less than 5 days on the panhandle. Maximum reported fog occurrence is 14 days during the morning hours at Luang Prabang. Haze and smoke occasionally reduce visibility to less than 2 mi in the northern highlands around sunrise. Showers and thundershowers, though occurring rarely in November, can reduce visibilities to less than 5 mi and, occasionally to less than 1 mi for brief periods. (See Figs. 12k and 13k.)

7. Wind and Temperatures Aloft: During November, northerly to northeasterly winds predominate over all of Laos. Mean speeds increase but local surface winds, both directions and speeds, are influenced by local topography and can deviate significantly from mean winds. When the Siberian High is strong, or when it shifts southward, wind speeds are stronger than normal. Most cases of strong gusty surface winds are associated with thunderstorm activity but high winds can also be caused by channeling (Venturi effect) through mountain valleys and passes.

There is insufficient data on which to base firm estimates of extreme surface winds over Laos but considering similar circumstances over Vietnam wind gusts in the 60 to 70 kt range would not be improbable.

Easterly to northeasterly winds extend aloft to about 8,000 ft north of 20°N latitude and to above 30,000 ft south of 17°N latitude. North of 17°N latitude the lower-level easterly flow is topped by westerly winds.

During November the mean freezing level ranges from 15,000 ft in the north to 16,000 ft in the south. Upper air temperatures are close to -18C at 25,000 ft throughout the year.

8. Combined Ceiling and Visibility: Combined ceilings and visibilities are poorest during the early morning hours near sunrise with visibilities being the major restrictant. Ceilings of 5,000 ft or more accompanied by visibilities of at least 5 mi ($\geq$5000/5) occur less than 30% of the time over most of the eastern half of the country at 0700 LST. The best region, at this time of day, is along the Mekong River Valley south of Boneng where frequencies are 90% or more. There is general improvement in these conditions between early morning and mid-afternoon although no change in basic pattern. By 1600 LST $\geq$5000/5 occurs as frequently as 70% or more of the time over almost half of the country. Along parts of the Chaine Annamatique and in the region around Sam Neua the frequency is still 10% or less.

The frequency of $\geq$1000/2 1/2 is also at a minimum during the early morning hours and is less than 50% along the higher ridges of the eastern

border region. Conditions are best along the Mekong Valley and over the northwestern part of the country southwest of Phong Saly where the percentages exceed 90%. Considerable improvement in those regions of lowest frequency takes place by mid-afternoon; however, no significant change in the basic patter occurs. By 1600 LST frequencies lower than 70% are confined to the higher ridges of the eastern border. Over much of the country the frequency of $\geq$1000/2 1/2 exceeds 90%.

TEMPERATURE (°F)

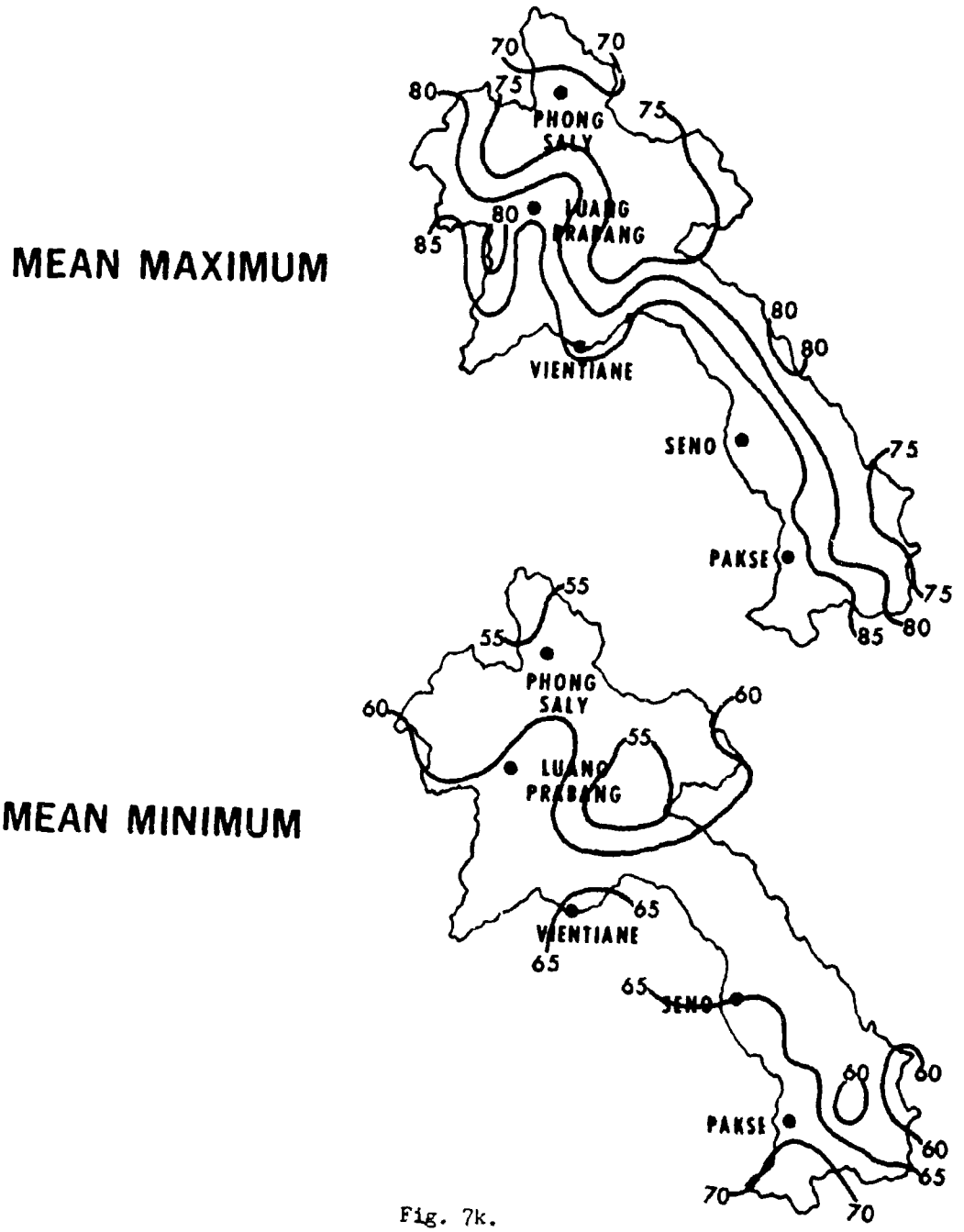


Fig. 7k.

NOV

MEAN RELATIVE HUMIDITY (%)

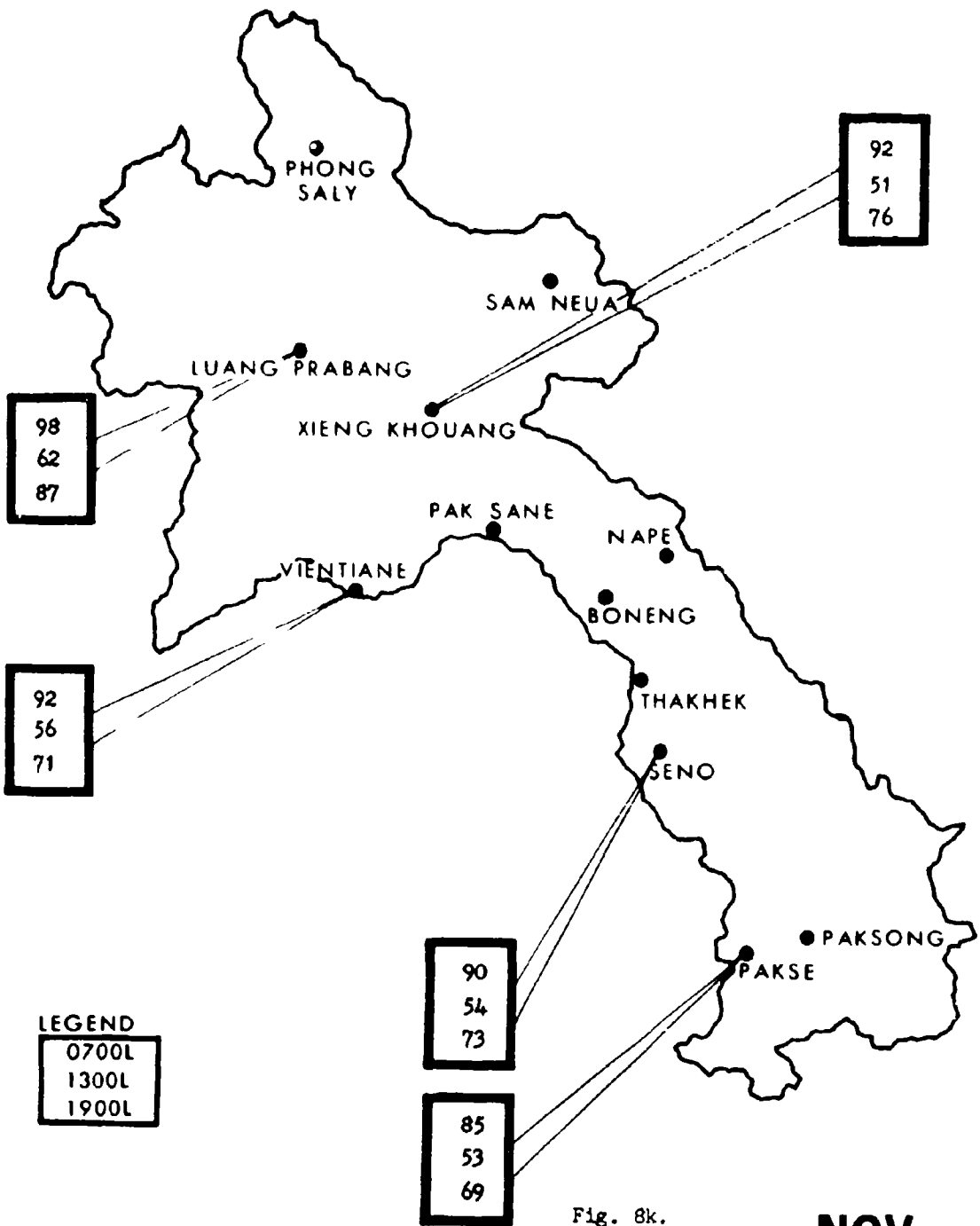


Fig. 8k.

NOV

MEAN NUMBER OF DAYS WITH PRECIPITATION

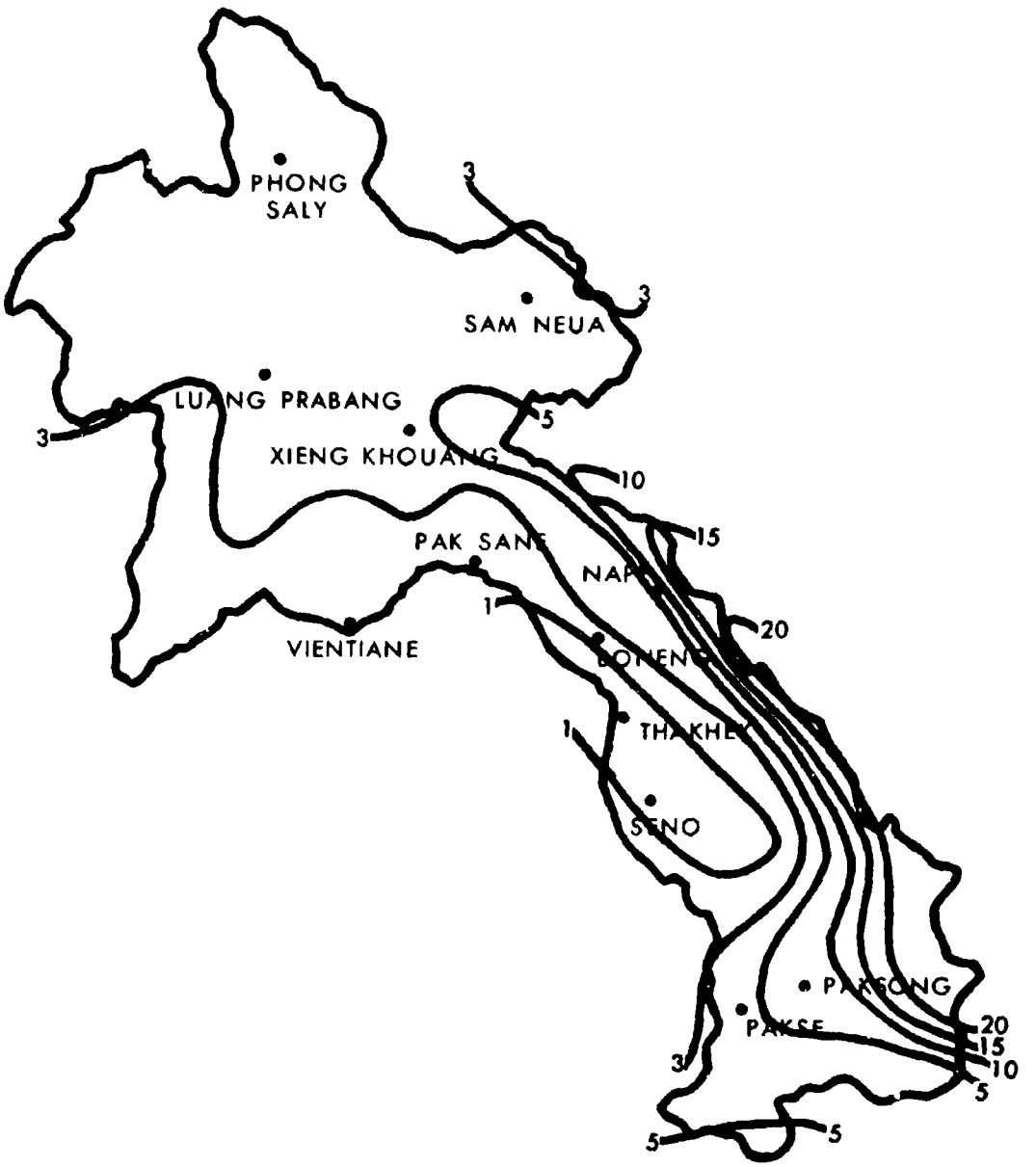


Fig. 9k.

NOV

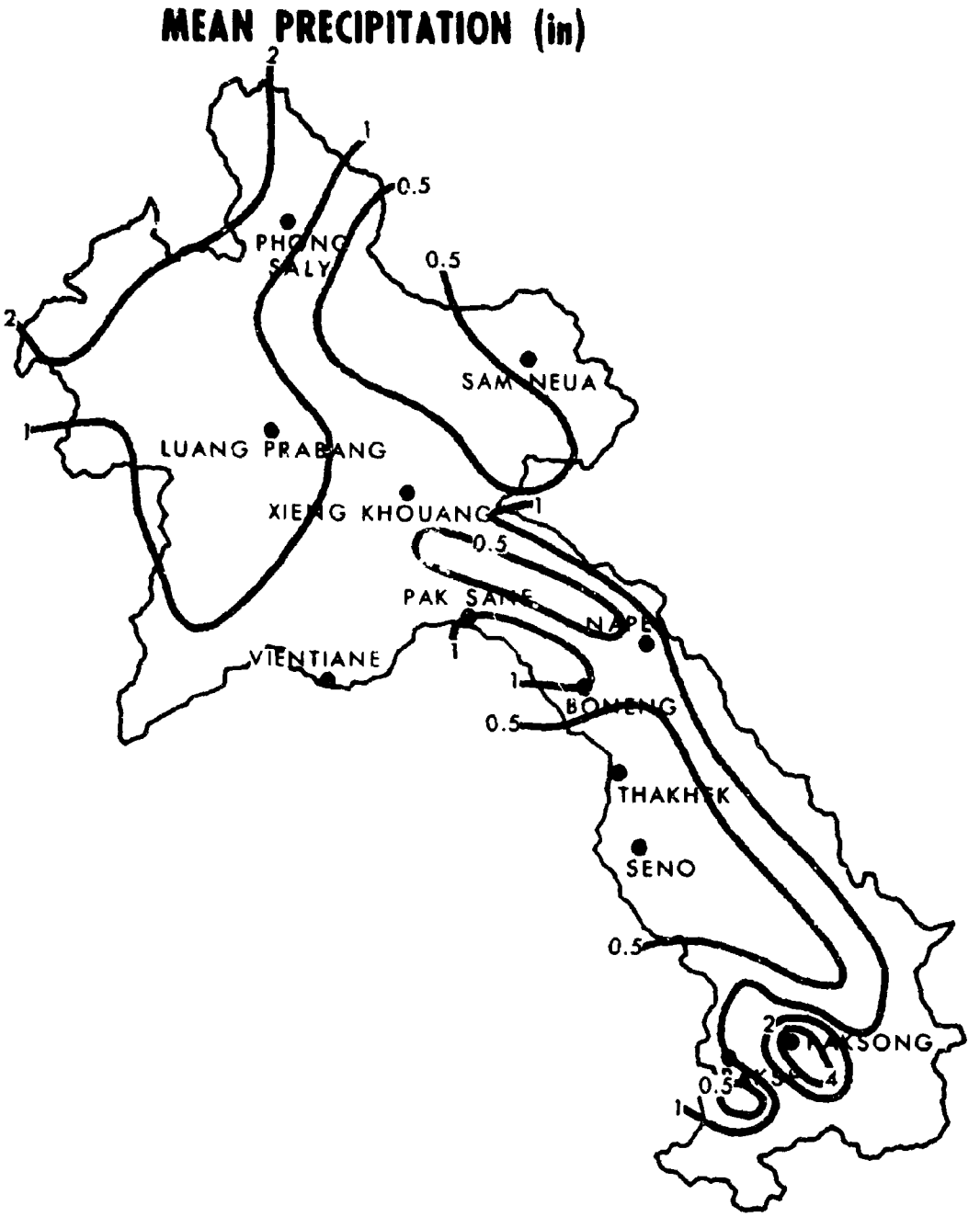

MEAN PRECIPITATION (in)
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BOLIKHAMSAI
THAKHEK
SENO
SAVANNAKHET
2
1
0.5
0.5
2
1
1
0.5
1
1
1
0.5
2
1
0.5
1
NOV

Fig. 10k

PRECIPITATION and THUNDERSTORMS

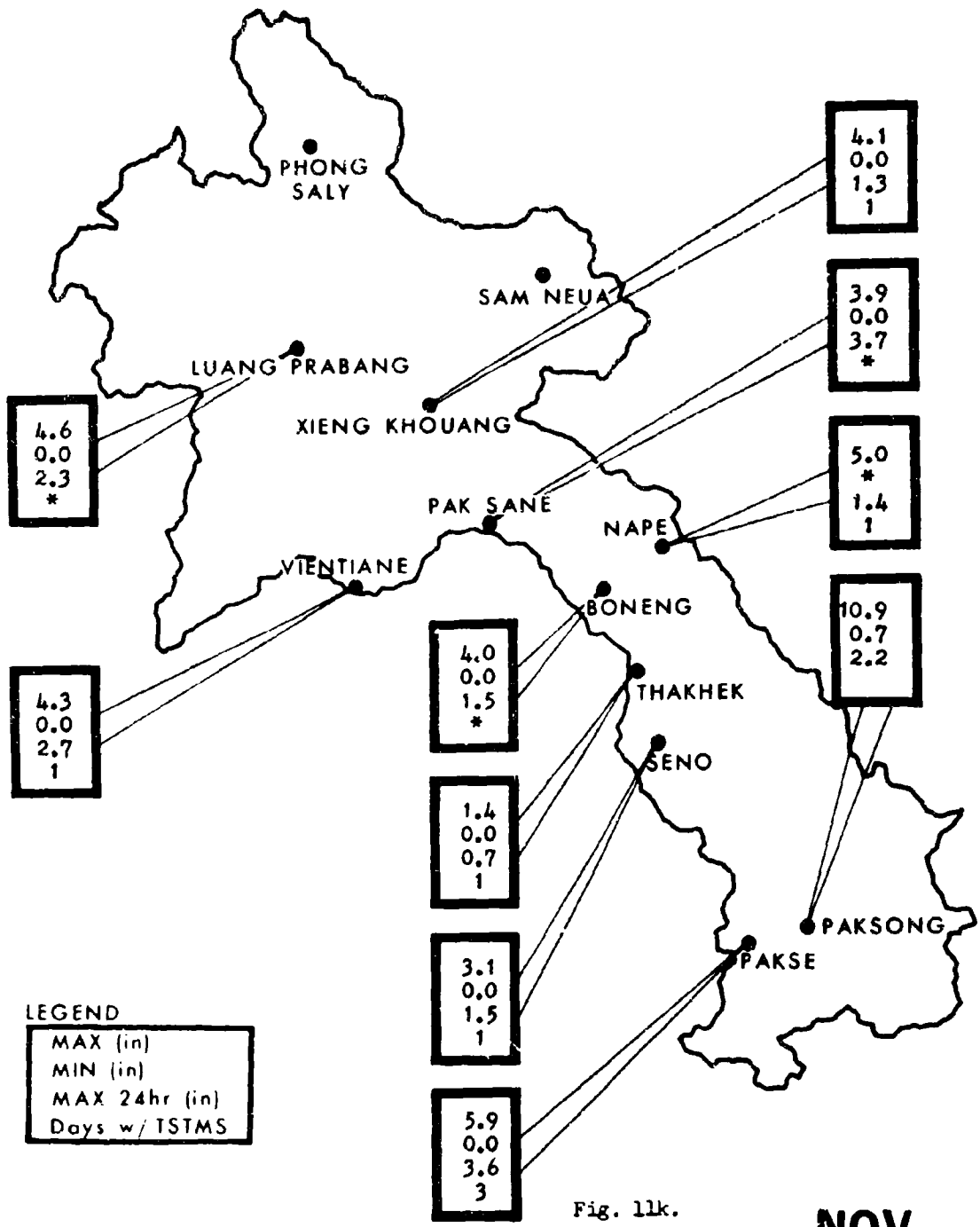


Fig. 11k.

NOV

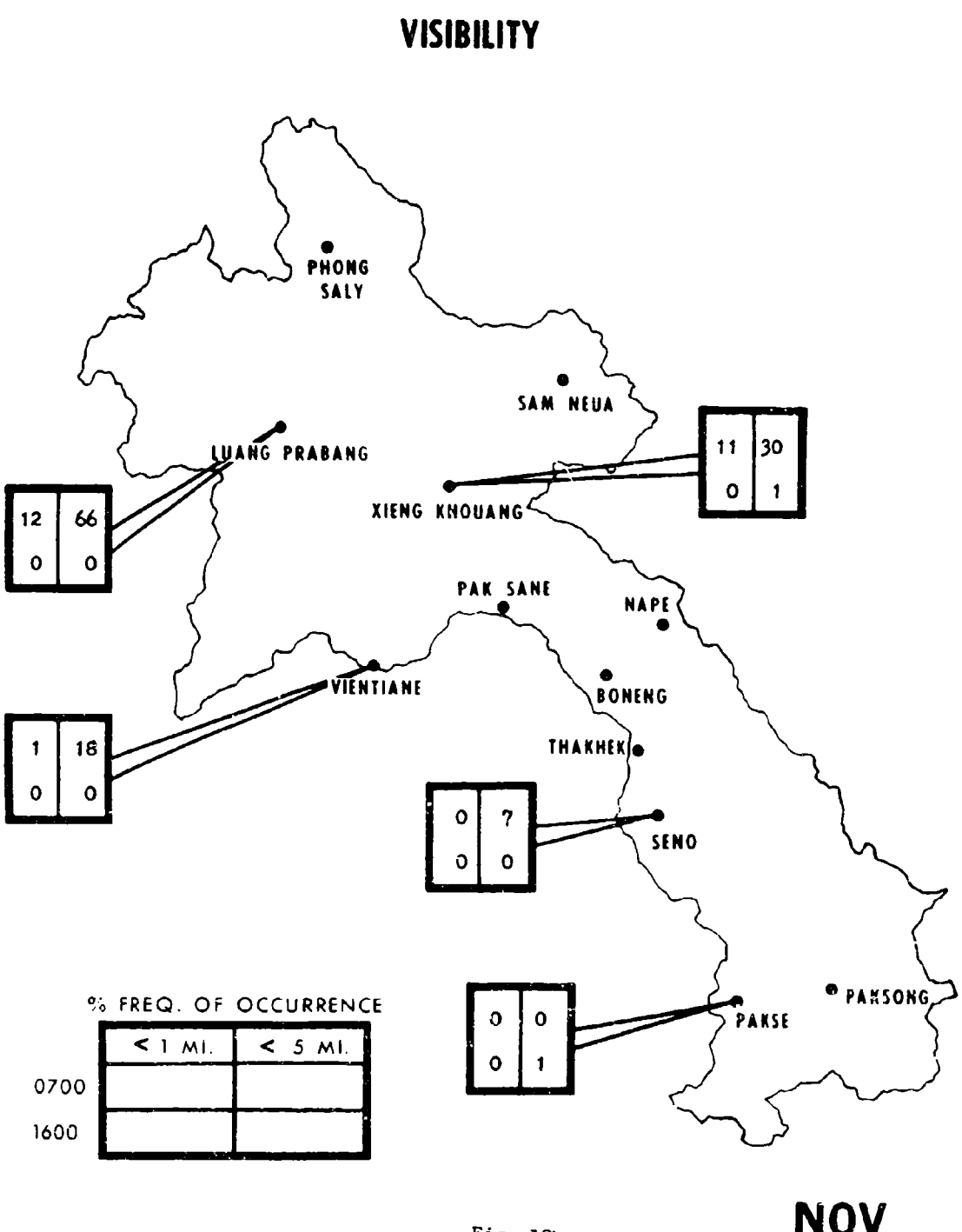

VISIBILITY
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
PAKSE
12 66
0 0
11 30
0 1
1 18
0 0
0 7
0 0
0 0
0 1
% FREQ. OF OCCURRENCE
< 1 MI. < 5 MI.
0700
1600
NOV

Fig. 12k.

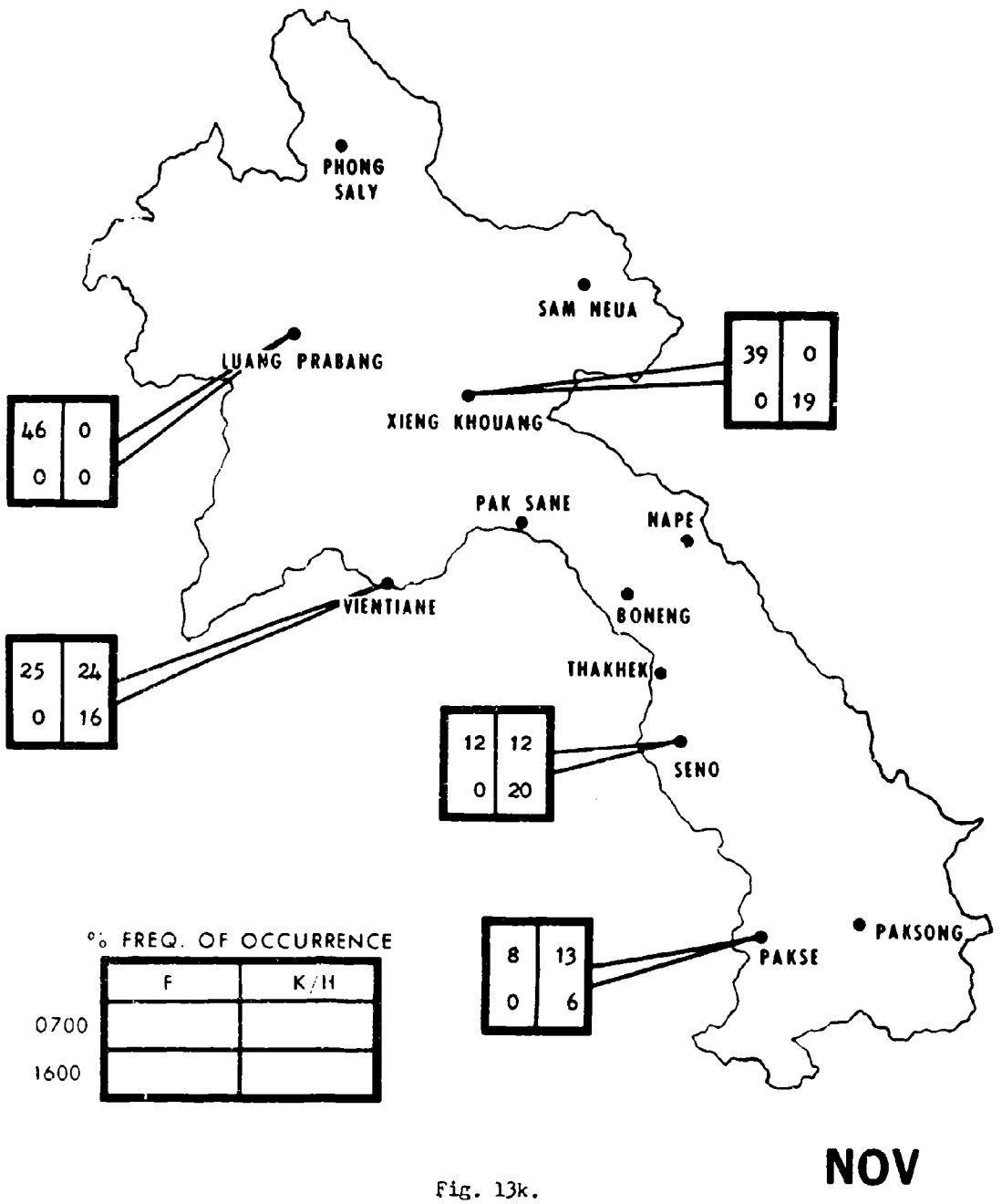

FOG-SMOKE/HAZE
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
PAKSE
46 0
0 0
39 0
0 19
25 24
0 16
12 12
0 20
8 13
0 6
% FREQ. OF OCCURRENCE
F
K/H
0700
1600
NOV

Fig. 13k.

CEILING/VISIBILITY

(0700 LST)

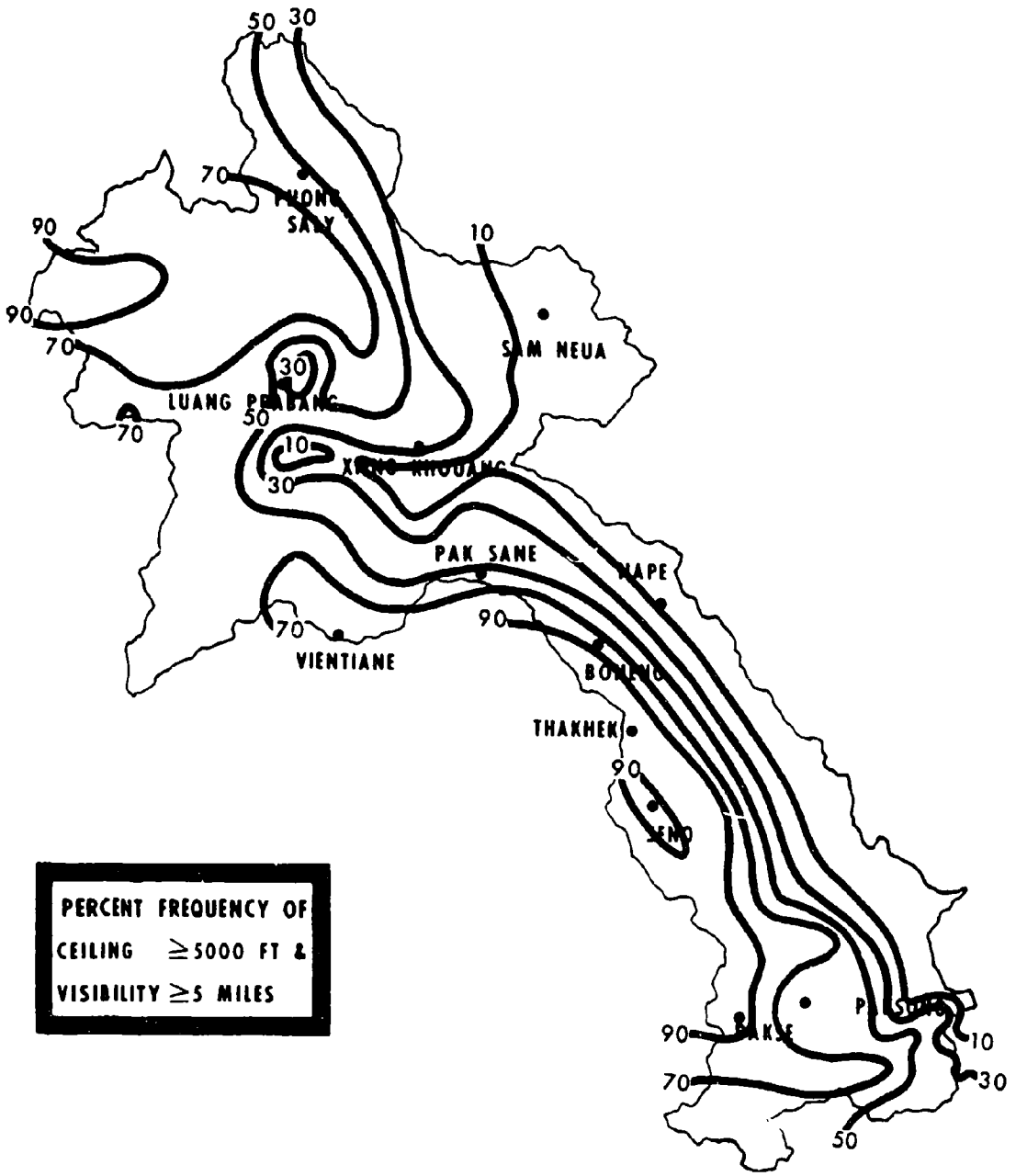


Fig. 1lk

NOV

CEILING/VISIBILITY

(1600 LST)

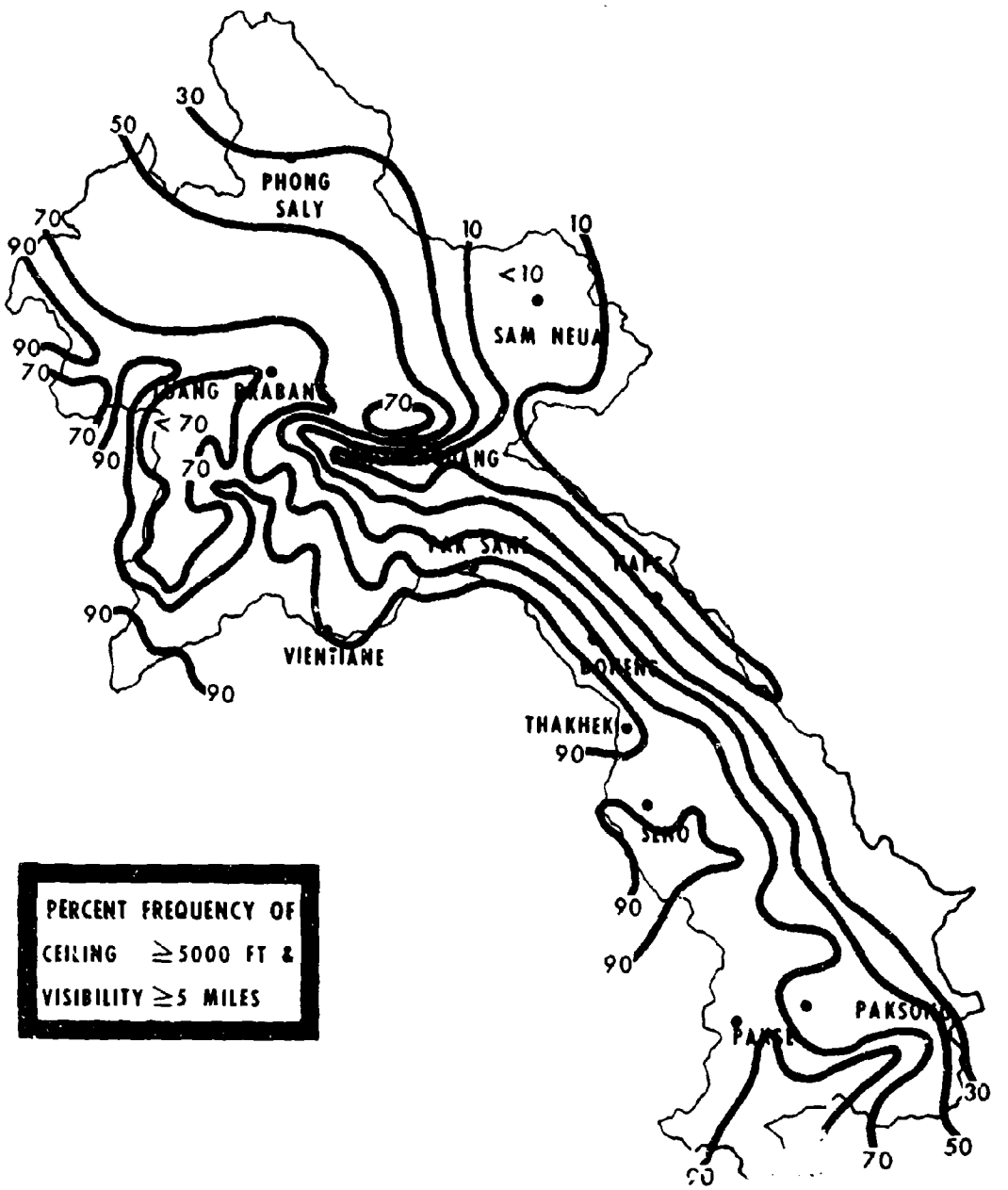


Fig. 15k

NOV

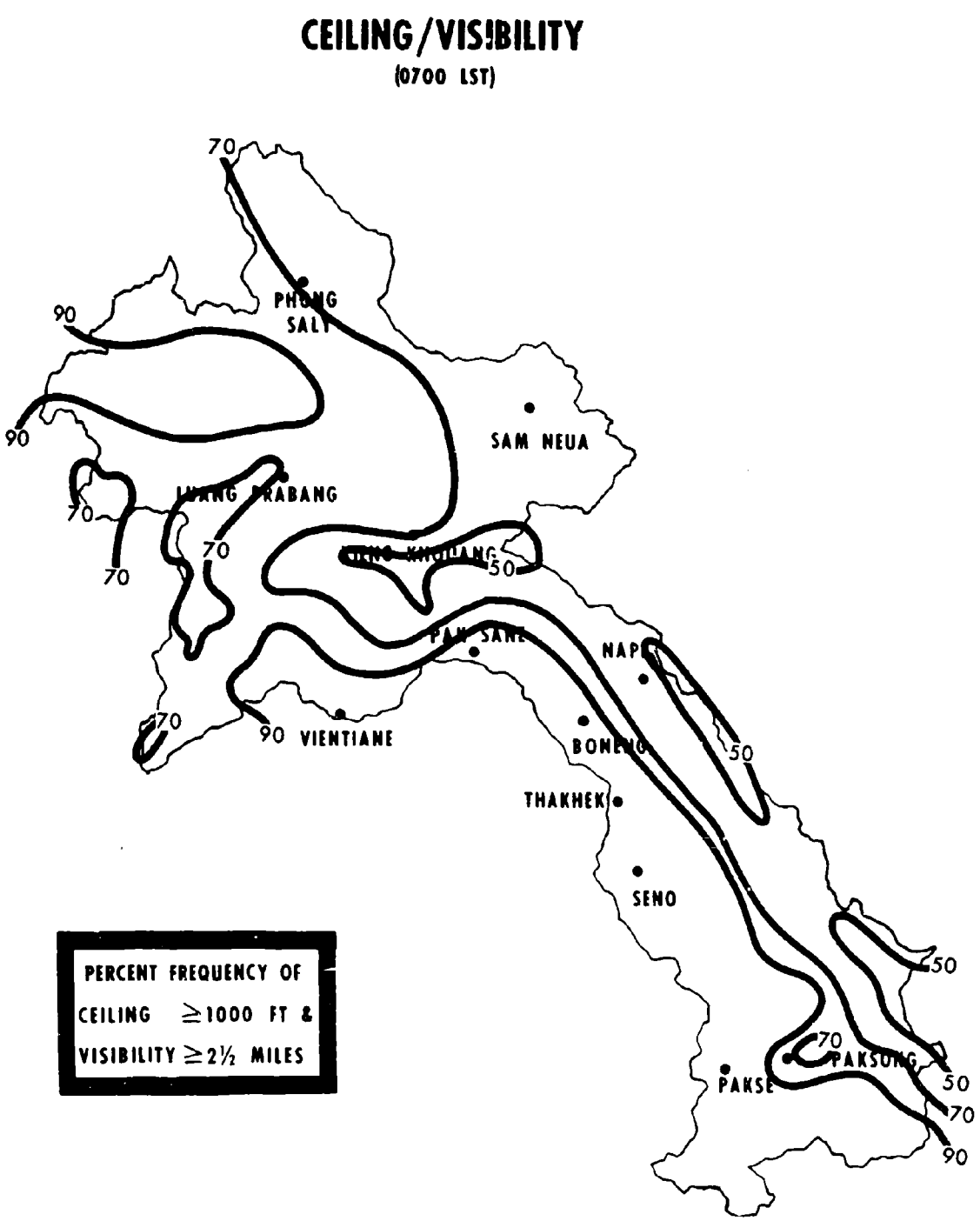

CEILING/VISIBILITY
(0700 LST)
70
90
PHONG SALY
90
SAM NEUA
LUANG PRABANG
70
70
70
50
PAK SANE
NAPE
70
90 VIENTIANE
BONENG
50
THAKHEK
SENO
50
70
PAKSONG
PAKSE
50
70
90
PERCENT FREQUENCY OF
CEILING ≥1000 FT &
VISIBILITY ≥2½ MILES
NOV

Fig. 16k

CEILING/VISIBILITY

(1600 LST)

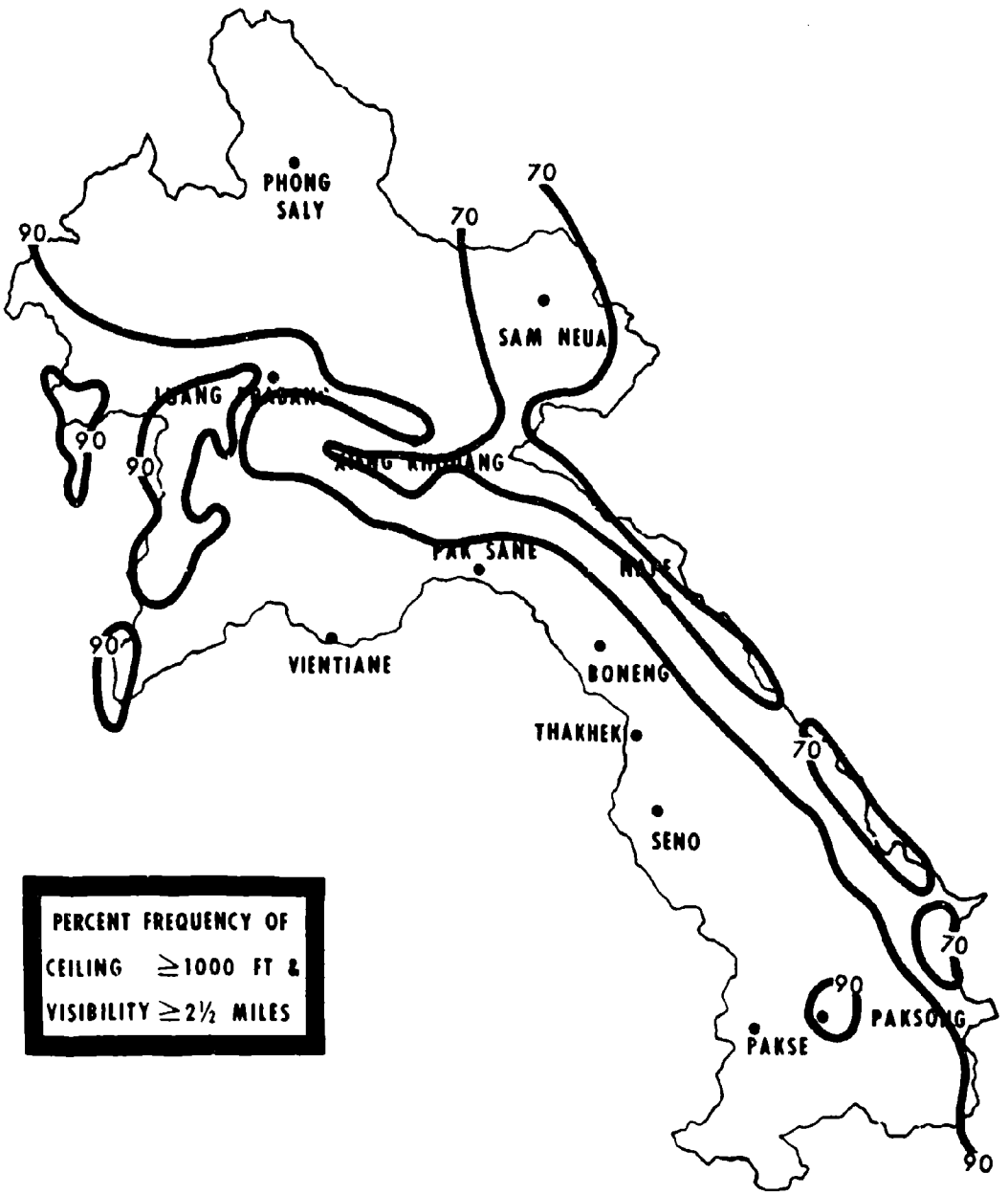


Fig. 17k

NOV

NOVEMBER SUNRISE, SUNSET AND TWILIGHT FOR VIENTIANE (17°59'N, 102°34'E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0520	0546	0609	1738	1800	1826	1.2	-1.2
2	0521	0547	0609	1737	1800	1826	1.2	-1.2
3	0521	0547	0609	1737	1759	1825	1.2	-1.2
4	0521	0547	0610	1737	1759	1825	1.2	-1.2
5	0522	0548	0610	1736	1759	1825	1.2	-1.3
6	0522	0548	0611	1736	1758	1824	1.3	-1.3
7	0523	0549	0611	1735	1758	1824	1.3	-1.3
8	0523	0549	0612	1735	1758	1824	1.3	-1.3
9	0523	0549	0612	1735	1757	1824	1.3	-1.4
10	0524	0550	0613	1734	1757	1823	1.4	-1.4
11	0524	0550	0613	1734	1757	1823	1.4	-1.4
12	0525	0551	0614	1734	1757	1823	1.4	-1.4
13	0525	0551	0614	1734	1756	1823	1.4	-1.5
14	0526	0552	0615	1733	1756	1823	1.4	-1.5
15	0526	0552	0615	1733	1756	1822	1.5	-1.5
16	0526	0553	0616	1733	1756	1822	1.5	-1.5
17	0527	0553	0616	1733	1756	1822	1.5	-1.5
18	0527	0554	0617	1733	1756	1822	1.5	-1.6
19	0528	0554	0617	1733	1756	1822	1.6	-1.6
20	0528	0555	0618	1732	1755	1822	1.6	-1.6
21	0529	0555	0618	1732	1755	1822	1.6	-1.6
22	0529	0556	0619	1732	1755	1822	1.6	-1.7
23	0530	0556	0620	1732	1755	1822	1.6	-1.7
24	0530	0557	0620	1732	1755	1822	1.7	-1.7
25	0531	0558	0621	1732	1755	1822	1.7	-1.7
26	0531	0558	0621	1732	1756	1822	1.7	-1.7
27	0532	0559	0622	1732	1756	1822	1.7	-1.8
28	0532	0559	0623	1732	1756	1822	1.8	-1.8
29	0533	0600	0623	1732	1756	1823	1.8	-1.8
30	0534	0600	0624	1733	1756	1823	1.8	-1.8

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 18k.

L. DECEMBER

1. Climatic Brief: During December, Laos is completely under the influence of the northeast monsoon. The Siberian High pressure center continues to intensify, pushing cold, dry air southward. As the cold dry air flows southward, it is gradually heated by contact with the warmer China coast and waters of the South China Sea. Over water, this polar air merges with warm, moist tropical air from the western Pacific and arrives over Southeast Asia much warmer and more moist than when it left the continent. However, compared with the southwest monsoon, the northeast monsoon is relatively cool and dry.

During the northeast monsoon, the most frequent cloudiness and precipitation occurs on windward slopes of the Annam Range and the east coasts of Vietnam. By the time the northeast flow crosses the mountain chain and enters Laos most of the cloud and precipitation producing moisture is removed. Thus, over Laos, precipitation amounts are generally less than 1 in. and fall in 1 or 2 isolated showers, while the remainder of the month is rainless.

Laos enjoys some of its best overall weather of the year. Skies are relatively cloudless and visibilities are generally good, although fog in northern valleys reduces visibility in this region. However, this fog usually dissipates prior to 1000 LST.

The cooling trend continues with most regions of Laos showing a 4 to 5F drop from November values. Mean temperatures range from the high 50's in the north to about 80F in the south. Relative humidity ranges from 65 to 80%.

2. Temperatures: During December, mean maximum and minimum temperatures are at or near their annual minima. No data are available for the region north of 20°N, but available data from neighboring countries indicate that maximum temperatures in this region range from near 60 to 75F. Maximums between 70 and 75F also occur at higher elevations in the Annam Range and in the southern panhandle. Mean maximums over the remainder of the country are between 80 and 90F. The highest reported mean maximum is 87F at Pakse and the lowest is 71F at Xieng Khouang. The extreme high temperature is 97F at Seno and Thakhek. Mean daily minimum temperatures are between 50 and 60F over most of the country. The lowest reported mean minimum is 47F at Xieng Khouang and the highest is 64F at Pakse. The extreme low temperature is 32F at Xieng Khouang. (See Fig 71.)

3. Relative Humidity: Absolute humidity values are relatively high over most of Laos throughout the year although they decrease slightly from November to December. Relative humidity values range from 71% at Pakse to 80% at Luang Prabang. The record low humidity is 17% at Boneng. The high humidity results in conditions favorable for mildew, corrosion and decay of susceptible items. High humidity makes the high temperatures seem even higher. (See Fig. 81.)

4. Precipitation and Thunderstorms: During December the northeast monsoon is firmly established over Laos and mean precipitation amounts are at or approaching their annual minimum. Rainfall is generally light and days with amounts in excess of 0.5 in. are rare. Most of the country can expect precipitation on 1 to 2 days during December. Maximum rainy days are 5 days at Nape and Pak Song. Mean precipitation values are less than 1 in. at most locations; however, on windward slopes of the Annam Range, amounts greater than 3 in. can be expected.

Reported maximum monthly values range from less than 1 in. at several locations along the Thailand border to 5 in. at Luang Prabang, but maximum amounts on exposed slopes of the panhandle are probably above 5 in. Minimum December amounts over most of Laos are zero. Monthly minimums above 1 in. occur over eastern slopes of the Annam Range along the Vietnam border. Maximum 24-hr precipitation amounts range from near zero at Seno to 3 in. at several widely separated locations.

Thunderstorms are almost non-existent over Laos at this time of year. The region of maximum activity is near Boneng where thunderstorms are reported on an average of 2 days per month; elsewhere they occur on less than 1 day a month on the average. (See Figs. 91, 101 and 111.)

5. Cloudiness: With northeasterly monsoonal winds dominating the area during December, cloudiness decreases over all of Laos. Cumulus clouds, with bases 2,000 to 3,000 ft, form after 1000 LST, but afternoon ceilings are infrequent. Around sunrise, 1,000 ft stratus ceilings may form in major river valleys but by 0900 LST they usually dissipate. Mean cloudiness varies from 27% at Thakhek to 58% at Luang Prabang. Widely scattered clouds (3/10 total sky cover or less) occur on 5 to 10 days in the northern mountains and windward slopes of the Annam Range, and on 17 to 22 days over the remainder of the country.

6. Visibility and Obstructions to Vision: Except in the northern valleys where early morning fog increases, there is little change in the incidence of low visibilities between November and December. Morning visibilities of less than 2 mi frequently occur in river valley fog, particularly in the north. Haze and smoke in northern highlands frequently reduce visibilities to less than 2 mi at sunrise. There is a decided increase in the occurrence of radiation fog in the northern part of the country. Fog can be expected on more than 10 days in the north and on less than 5 days in the panhandle. Maximum fog occurrence at regular reporting stations is 20 days at Luang Prabang. (See Figs. 121 and 131.)

7. Wind and Temperatures Aloft: During December, the prevailing low-level flow over Laos is northeasterly. Local surface winds, both directions and speeds, are influenced by local topography and deviate significantly from mean winds. When the Siberian High is strong, or when it shifts southward, wind speeds are stronger than normal. Channeling occurs

in mountain regions where valleys or passes face the prevailing wind resulting in higher speeds. The winds are compressed and packed, and the speeds increased as they flow through the narrow confines. No data are available for Laotian stations but similar conditions in Vietnam have resulted in winds as high as 70 kt.

Easterly to northeasterly winds extend aloft to about 8,000 ft. Westerly to southwesterly winds top the lower-level easterly flow.

During December the mean freezing level over Laos ranges from 14,500 ft in the north to 16,000 ft in the south. Upper air temperatures are close to -18C at 25,000 ft throughout the year.

8. Combined Ceiling and Visibility: Combined ceilings and visibilities are poorest during the early morning hours near sunrise with visibilities being the major restrictant. Ceilings of 5,000 ft or more accompanied by visibilities of at least 5 mi ($\geq$5000/5) occur less than 10% of the time over most of the eastern border area at 0700 LST. The best region, at this time of day, is along the Mekong River Valley south of Thakhek where frequencies are 90% or more. Except for those regions where percentages already exceed 90%, there is general improvement in conditions between early morning and mid-afternoon. By 1600 LST most of the region along the Mekong River experiences $\geq$5000/5 90% or more of the time. Along most of the eastern border area frequencies are still below 30%.

The frequency of $\geq$1000/2 1/2 is also at a minimum during the early morning hours and is less than 30% along the higher ridges of the eastern border region. Conditions are best along the Mekong Valley south of Boneng and near Vientiane where percentages exceed 90%. Considerable improvement in those regions of lowest frequency takes place by mid-afternoon; however, no significant change in the basic pattern occurs. By 1600 LST frequencies lower than 70% are confined to the eastern border area. Over more than half of the country the frequency of $\geq$1000/2 1/2 exceeds 90%.

TEMPERATURE (°F)

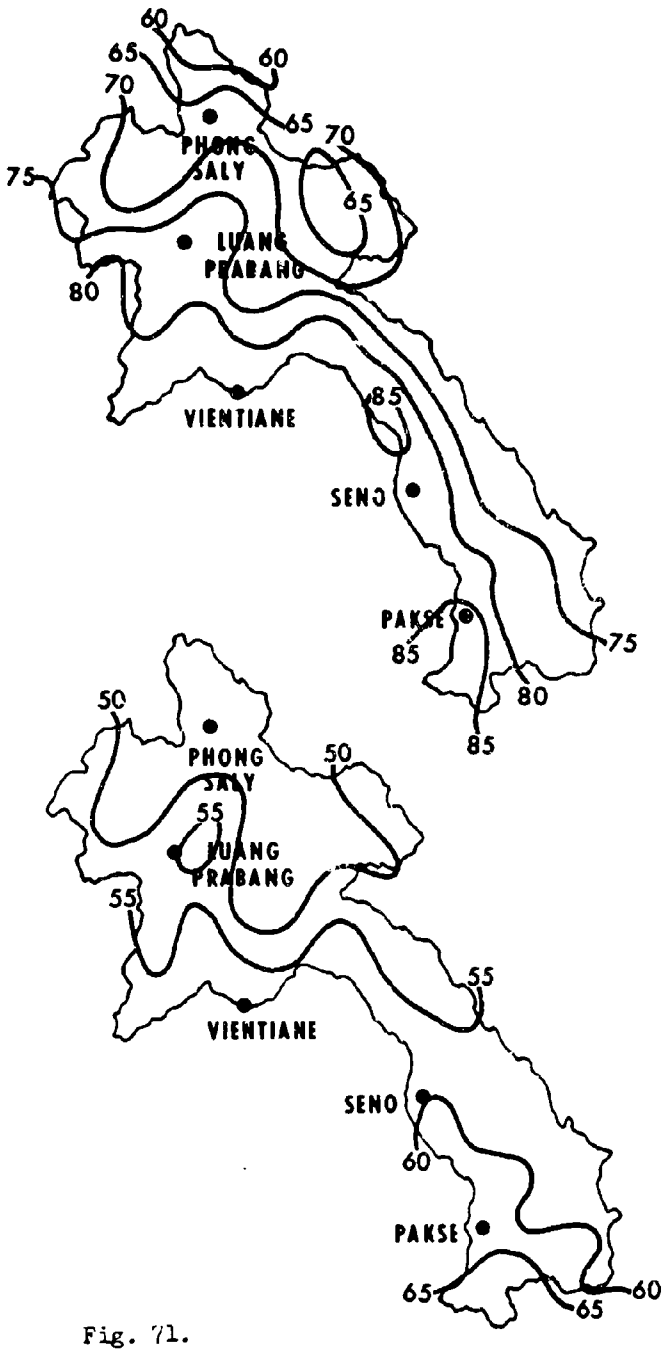


Fig. 71.

DEC

MEAN RELATIVE HUMIDITY (%)

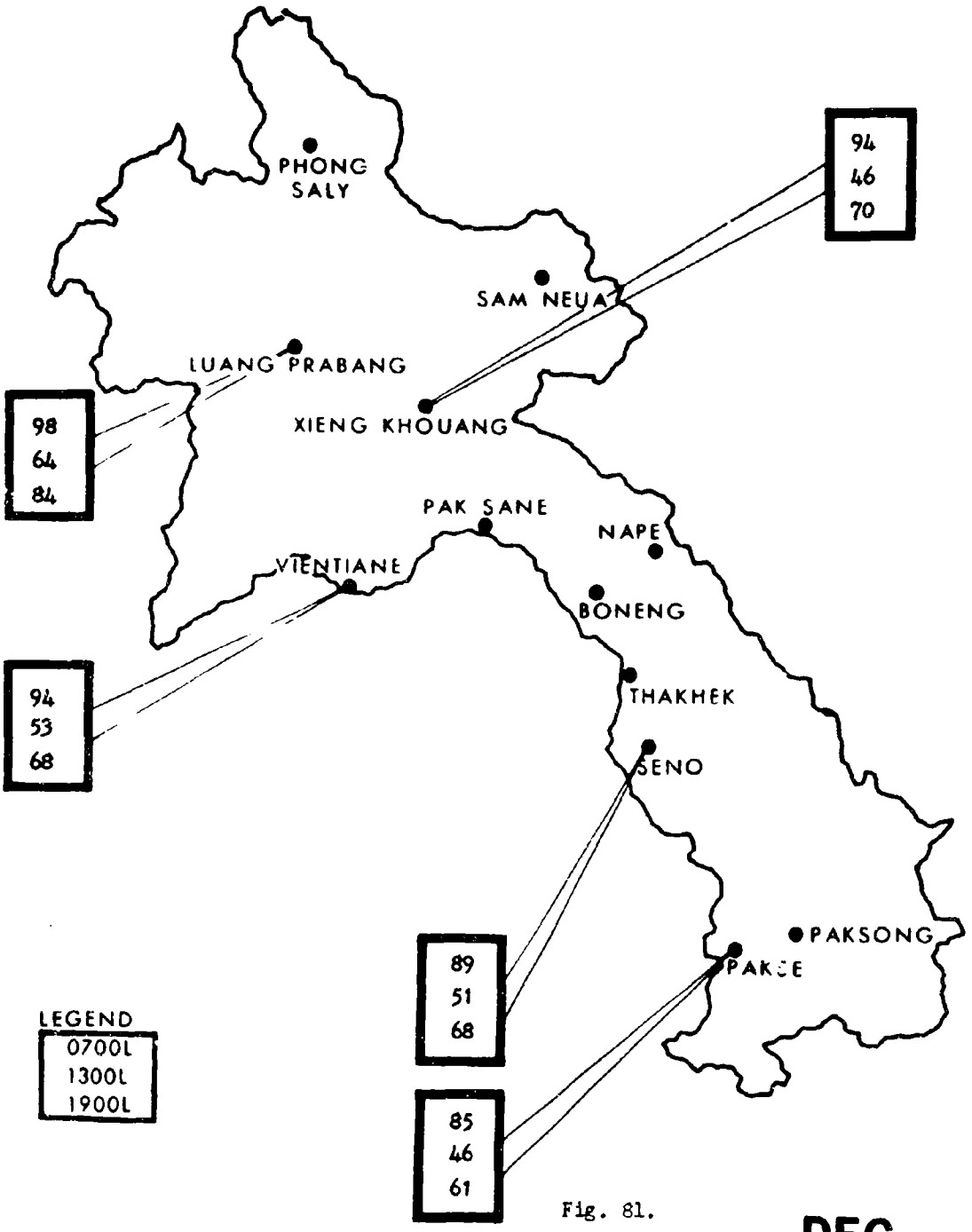


Fig. 81.

DEC

MEAN NUMBER OF DAYS WITH PRECIPITATION

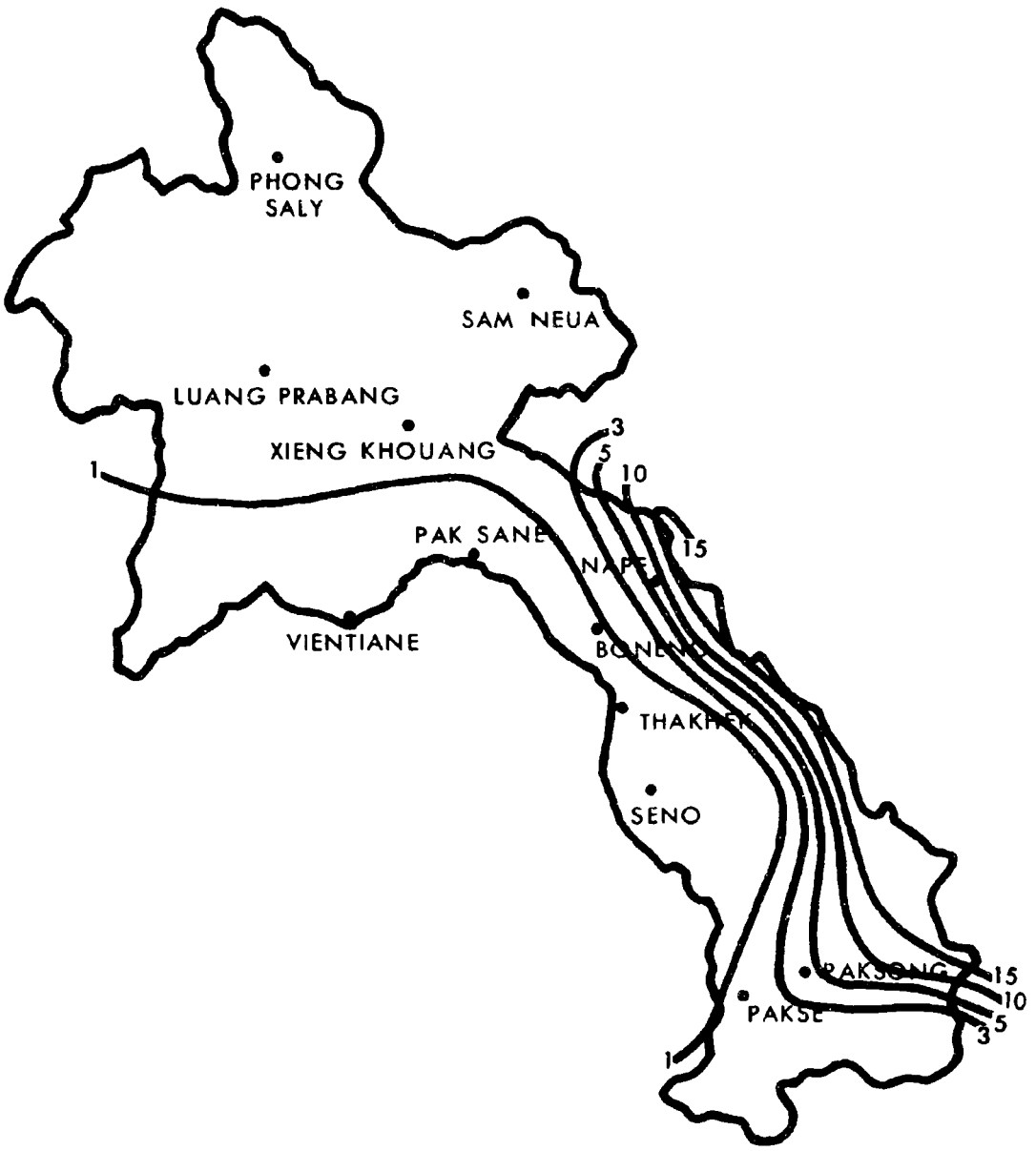


Fig. 91.

DEC

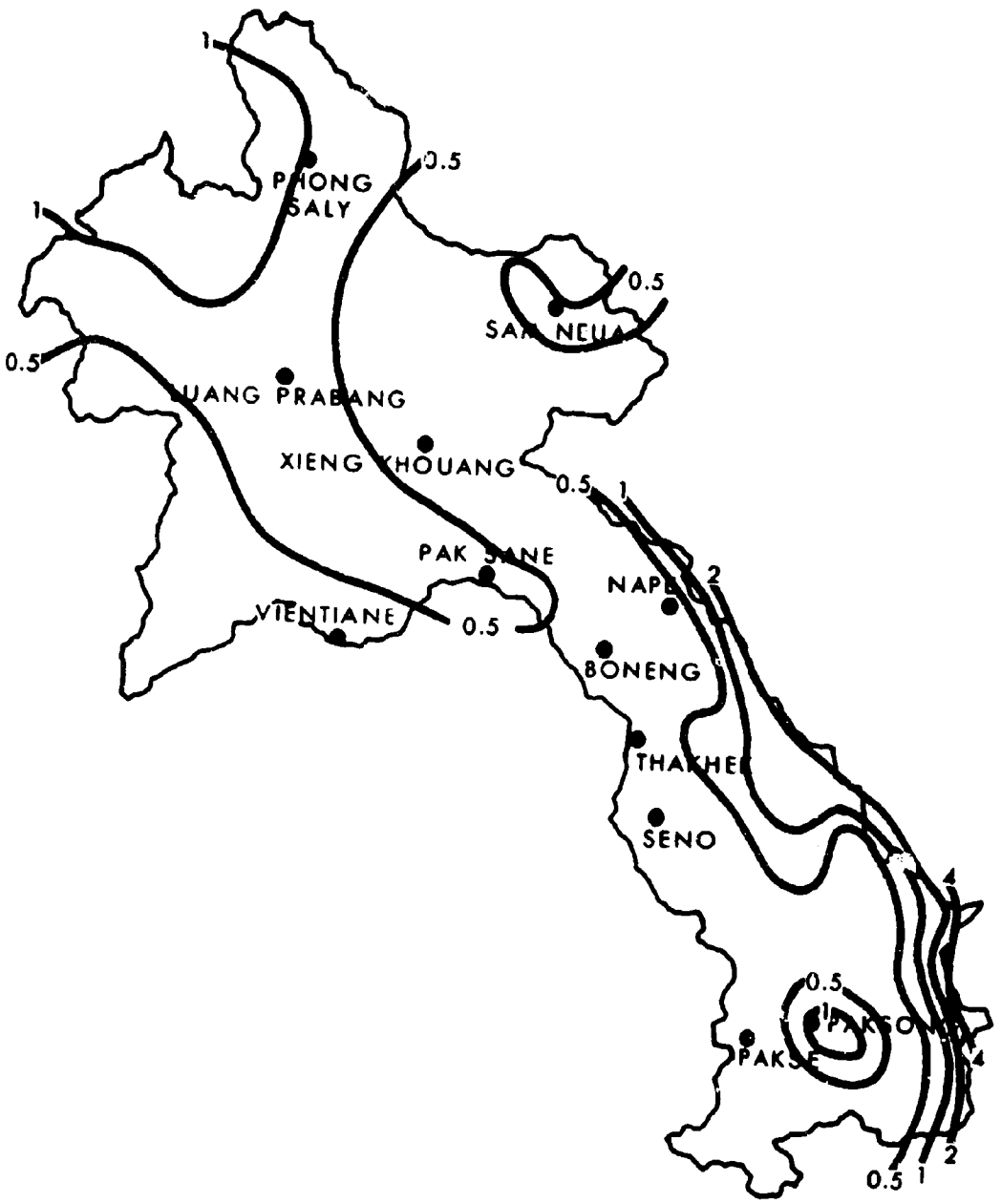

MEAN PRECIPITATION (in)
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
VIENTIANE
NAPE
BONENG
THAKHEK
SENO
PAKSE
PAKSONG
0.5
1
2
4
DEC

Fig. 101

PRECIPITATION and THUNDERSTORMS

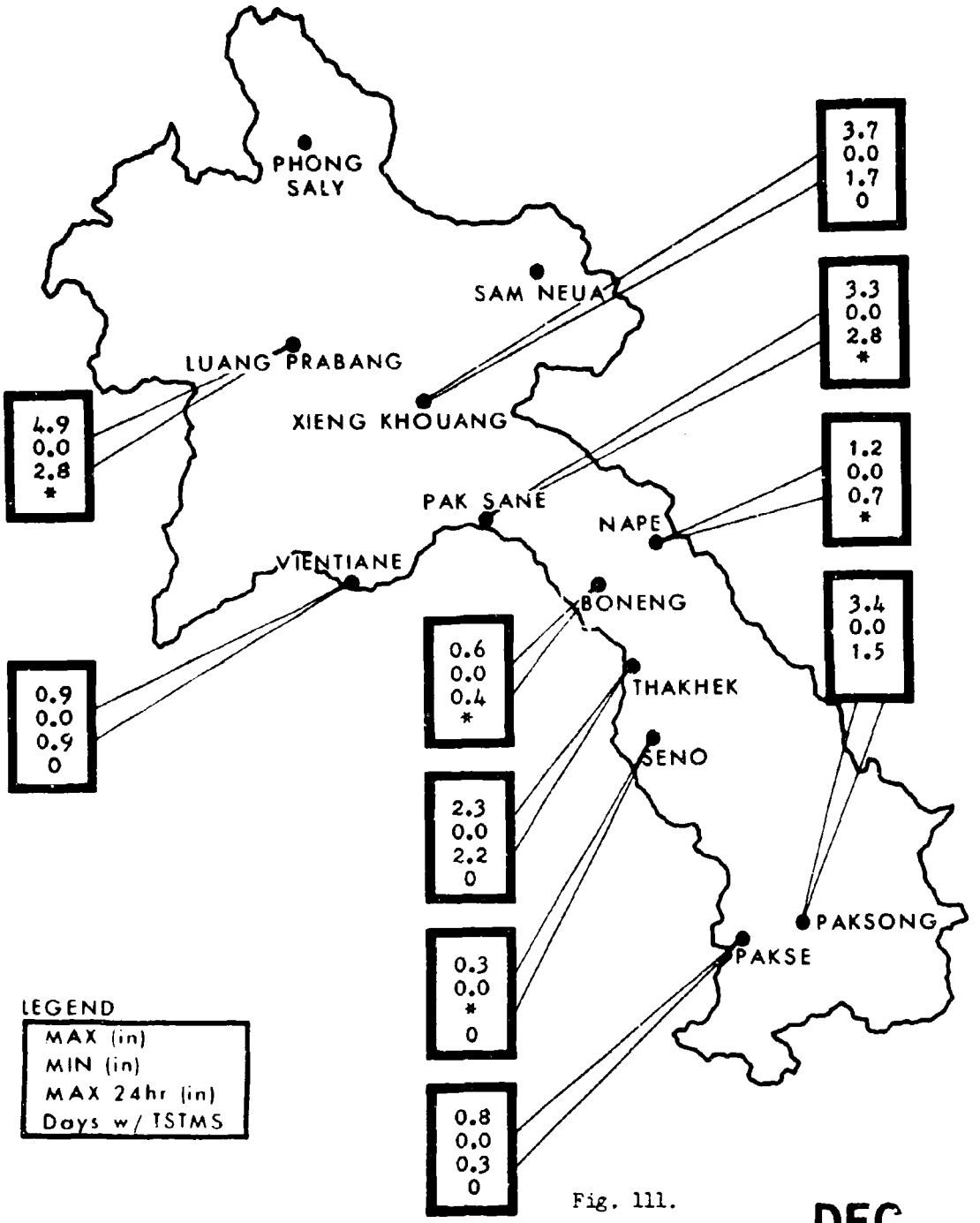


Fig. 111.

DEC

VISIBILITY

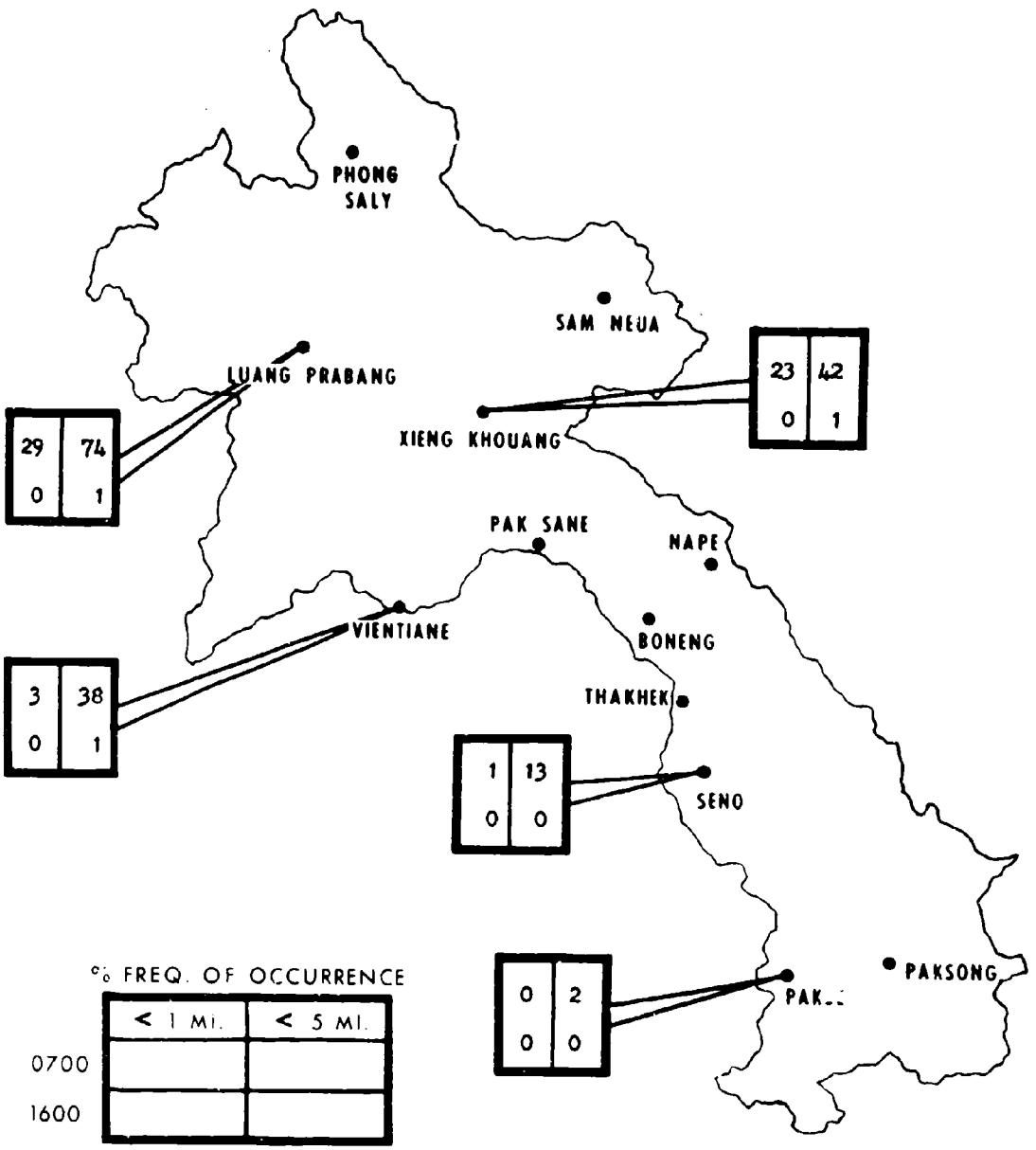


Fig. 121.

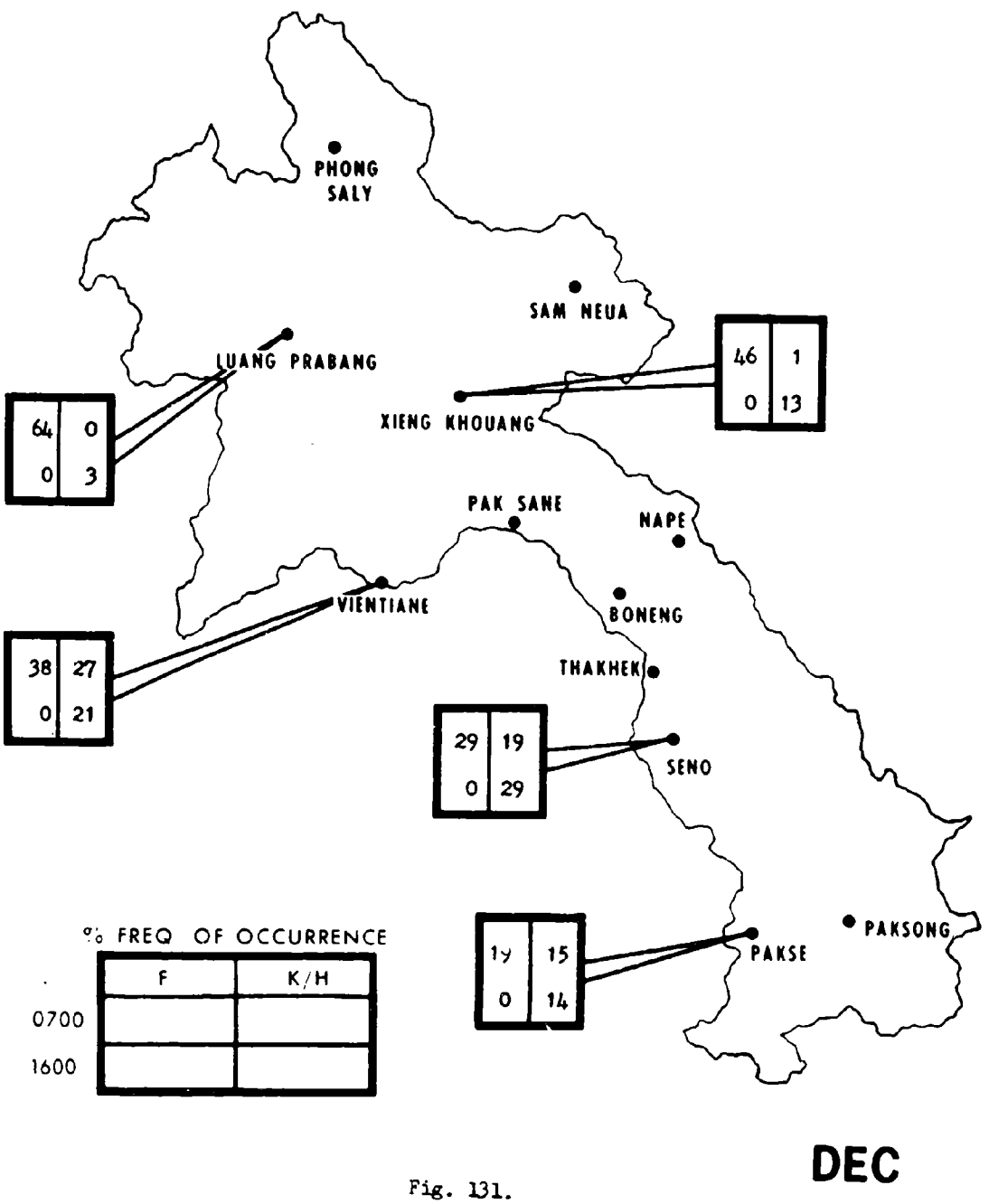

FOG-SMOKE/HAZE
PHONG SALY
SAM NEUA
LUANG PRABANG
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
PAKSONG
PAKSE
64 0
0 3
46 1
0 13
38 27
0 21
29 19
0 29
19 15
0 14
% FREQ OF OCCURRENCE
F
K/H
0700
1600
DEC

Fig. 131.

CEILING/VISIBILITY

(0700 LST)

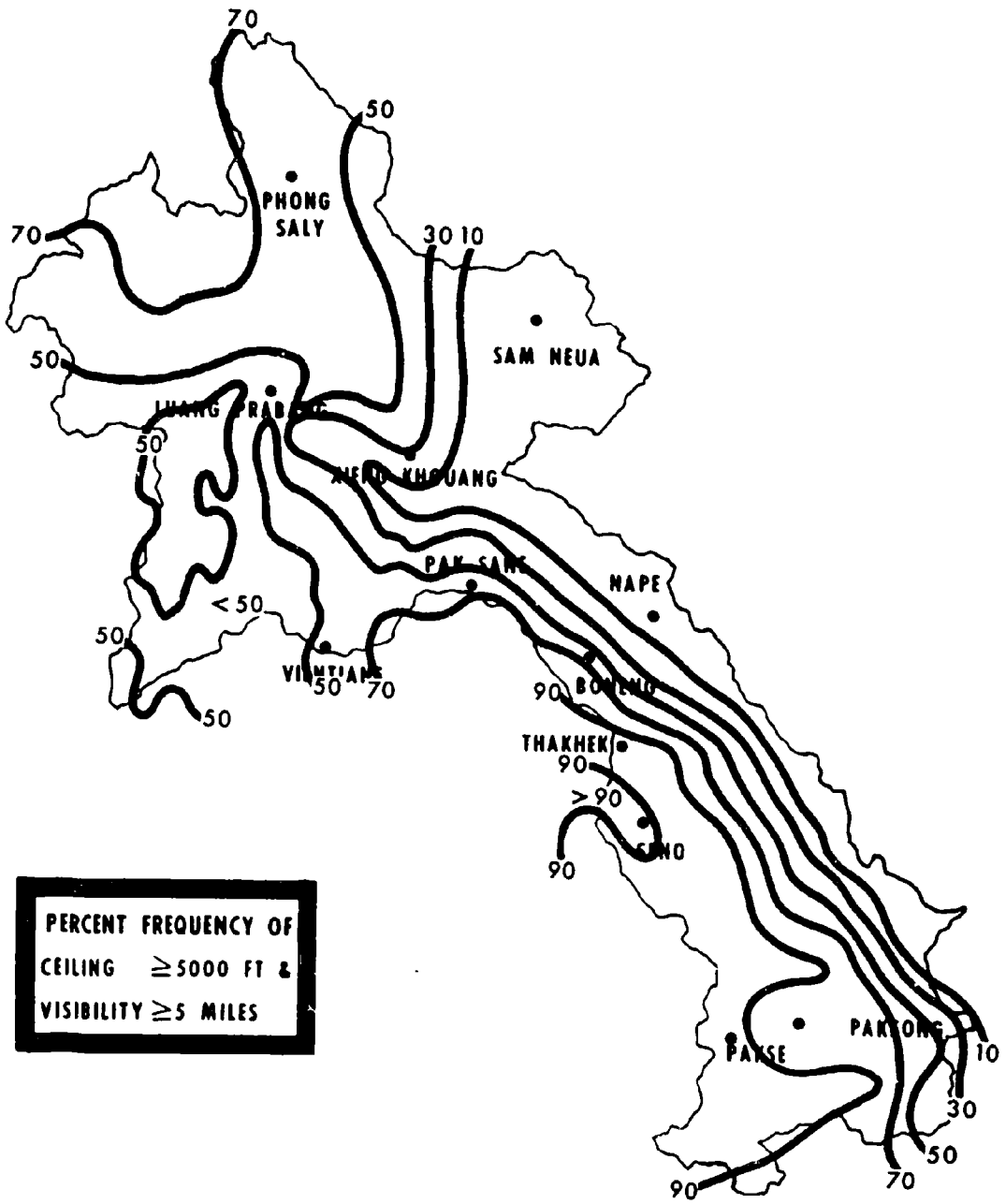


Fig. 141

DEC

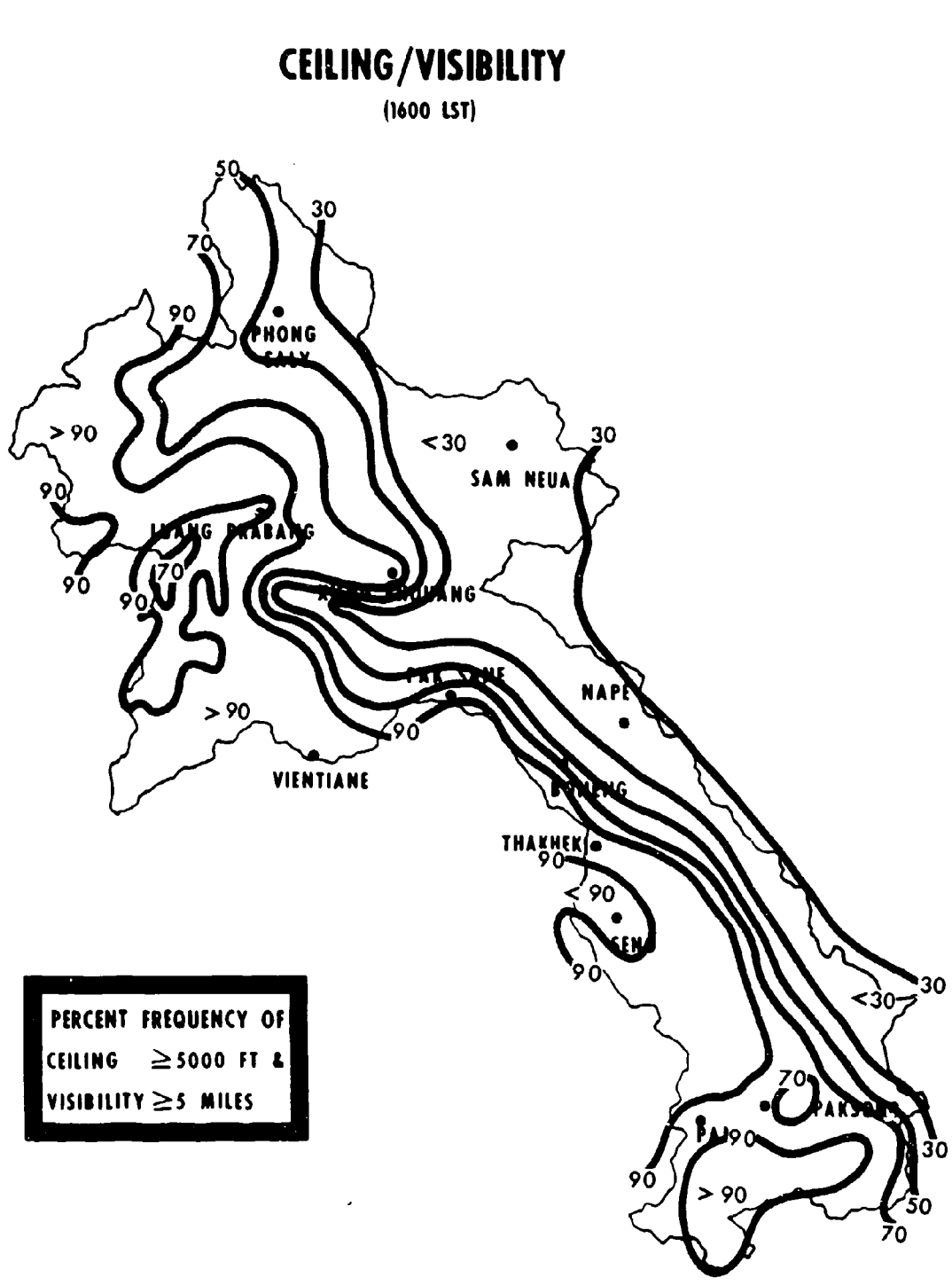

CEILING/VISIBILITY
(1600 LST)
50
30
70
90
PHONG SALY
>90
<30
30
SAM NEUA
90
90
70
90
90
NAPE
>90
90
VIENTIANE
THAKHEK
90
<90
90
<30
30
70
90
90
>90
30
50
70
PERCENT FREQUENCY OF
CEILING ≥5000 FT &
VISIBILITY ≥5 MILES
DEC

Fig. 151

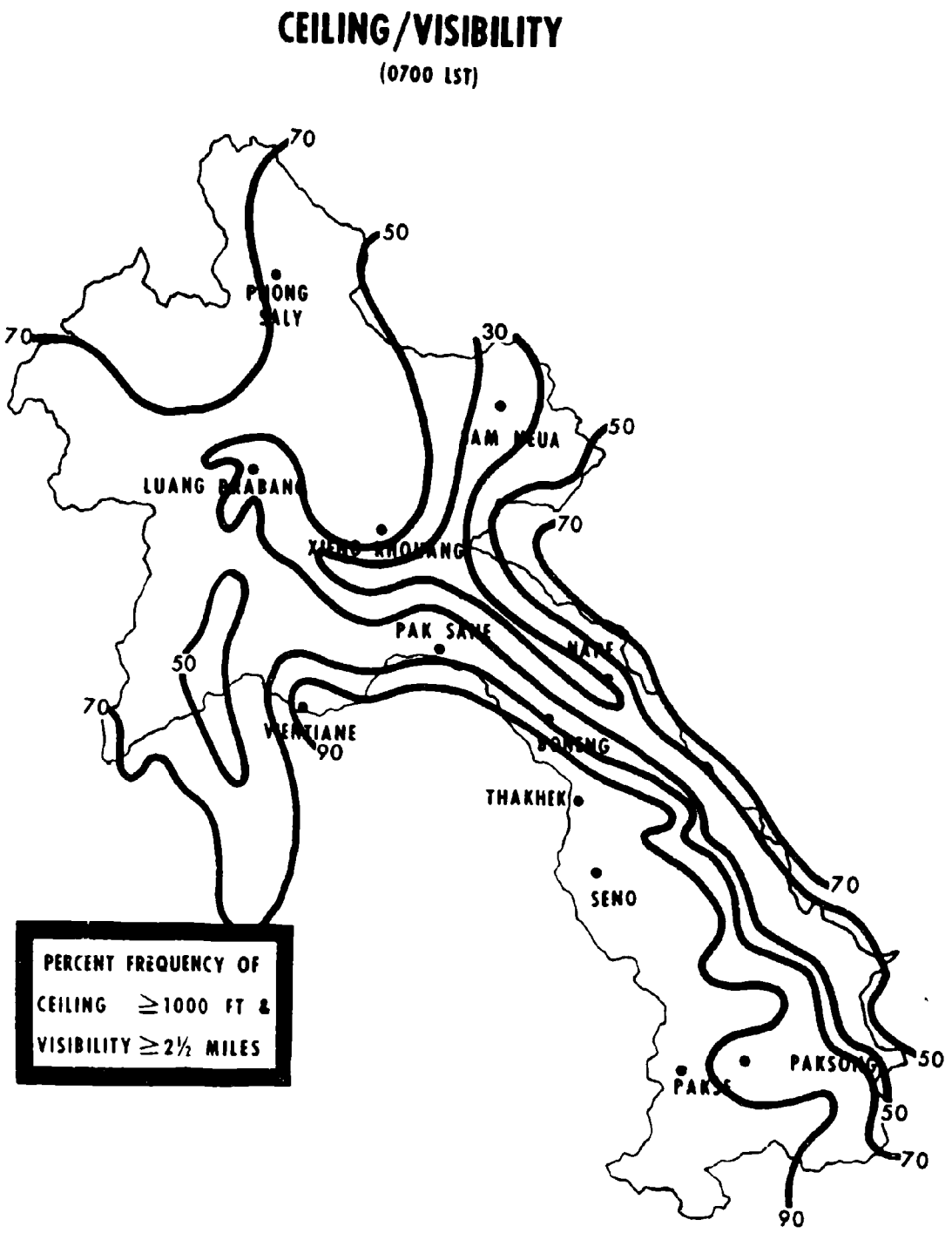

CEILING/VISIBILITY
(0700 LST)
70
50
PHONG SALY
70
30
AM NEUA
50
LUANG PRABANG
70
PAK SANE
50
70
VIENTIANE
90
THAKHEK
SENO
70
PAKSE
50
50
70
90
PERCENT FREQUENCY OF
CEILING ≥1000 FT &
VISIBILITY ≥2½ MILES
DEC

Fig. 161

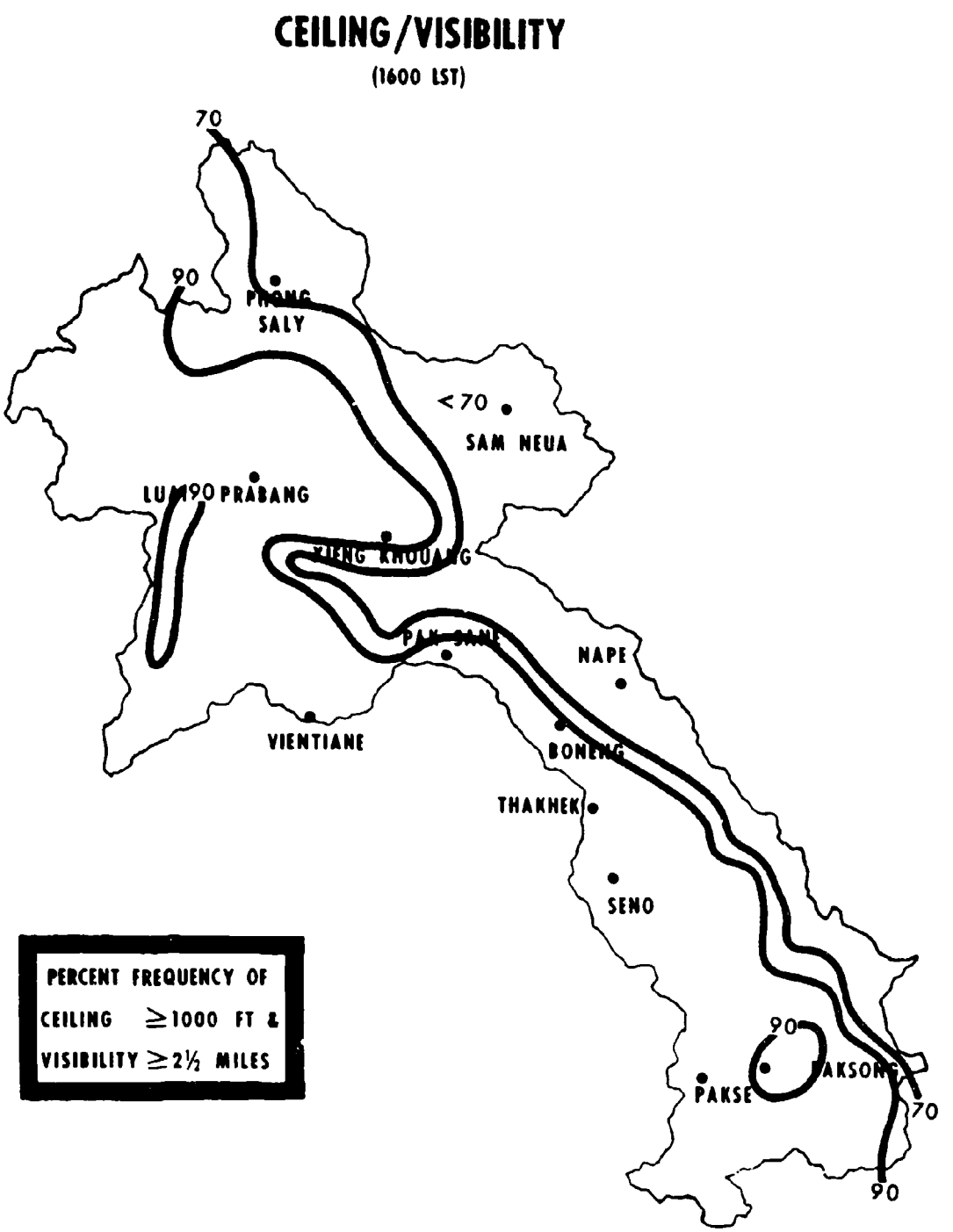

CEILING/VISIBILITY
(1600 LST)
70
90
PHONG SALY
<70
SAM NEUA
LUANG PRABANG
90
XIENG KHOUANG
PAK SANE
NAPE
VIENTIANE
BONENG
THAKHEK
SENO
90
PAKSE
PAKSONG
70
90
PERCENT FREQUENCY OF
CEILING ≥1000 FT &
VISIBILITY ≥2½ MILES

Fig. 171

DEC

DECEMBER SUNRISE, SUNSET AND TWILIGHT FOR VIENTIANE (17°59'N, 102°34'E)

Date	BMNT	BMCT	Sunrise	Sunset	EECT	EENT	LDFSR	LDFSS
1	0534	0601	0624	1733	1756	1823	1.8	-1.8
2	0535	0602	0625	1733	1756	1823	1.8	-1.8
3	0535	0602	1726	1733	1756	1823	1.8	-1.8
4	0536	0603	1726	1733	1757	1824	1.8	-1.8
5	0536	0603	0627	1733	1757	1824	1.8	-1.8
6	0537	0604	0627	1734	1757	1824	1.9	-1.8
7	0537	0604	0628	1734	1757	1824	1.9	-1.9
8	0538	0605	0629	1734	1758	1825	1.9	-1.9
9	0539	0606	0629	1734	1758	1825	1.9	-1.9
10	0539	0606	0630	1735	1758	1825	1.9	-1.9
11	0540	0607	0630	1735	1759	1826	1.9	-1.9
12	0540	0607	0631	1735	1759	1826	2.0	-1.9
13	0541	0608	0632	1736	1759	1827	2.0	-2.0
14	0541	0608	0632	1736	1800	1827	2.0	-2.0
15	0542	0609	0633	1736	1800	1827	2.0	-2.0
16	0542	0610	0633	1737	1801	1828	2.0	-2.0
17	0543	0610	0634	1737	1801	1828	2.0	-2.0
18	0543	0611	0634	1738	1801	1829	2.0	-2.0
19	0544	0611	0635	1738	1802	1829	2.0	-2.0
20	0545	0612	0635	1739	1802	1830	2.0	-2.0
21	0545	0612	0636	1739	1803	1830	2.0	-2.0
22	0546	0613	0636	1740	1803	1831	2.0	-2.0
23	0546	0613	0637	1740	1804	1831	2.0	-2.0
24	0547	0614	0637	1741	1804	1832	2.0	-1.9
25	0547	0614	0638	1741	1805	1832	2.0	-1.9
26	0547	0615	0638	1742	1805	1833	2.0	-1.9
27	0548	0615	0639	1742	1806	1833	1.9	-1.9
28	0548	0616	0639	1743	1807	1834	1.9	-1.9
29	0549	0616	0640	1743	1807	1834	1.9	-1.9
30	0549	0616	0640	1744	1808	1835	1.9	-1.9
31	0550	0617	0640	1745	1808	1835	1.9	-1.9

ABBREVIATIONS

BMNT - Beginning Morning Nautical Twilight (sun 12° below horizon)
BMCT - Beginning Morning Civil Twilight (sun 6° below horizon)
EECT - Ending Evening Civil Twilight (sun 6° below horizon)
EENT - Ending Evening Nautical Twilight (sun 12° below horizon)
LDFSR - Latitudinal Displacement Factor Sunrise (in minutes)
LDFSS - Latitudinal Displacement Factor Sunset (in minutes)

Fig. 181.

ASTRONOMICAL DATA COMPUTATION METHOD

The astronomical data for Vientiane presented in Figs. 18a through 18l may be used to compute similar data for any other point in Laos. For example, to compute the time of sunset at Pakse on 21 December utilize the following procedure:

1. Make a longitudinal time correction by algebraically subtracting the longitude of Pakse from the longitude of Vientiane. Convert the difference to decimal form and multiply by 4 minutes (the time required for the earth to turn 1° longitude) and algebraically add to Vientiane's sunset.

Long. Vientiane	102°34'	-3°13' = -3.2°
Long. Pakse	105°47'	4 X -3.2 = -12.8 min
	-3°13'	

1739	LST (Sunset at Vientiane)
-13	(algebraic addition)
1726	LST (longitude corrected sunset)

2. Make latitudinal time correction by algebraically subtracting the latitude of Pakse from the latitude of Vientiane. Convert the difference to decimal form, and multiply by LDFSS. Algebraically subtract the product from the longitude corrected sunset.

Lat. Vientiane	17°59'	+2°52' = +2.9°
Lat. Pakse	15°07'	-2.0 (LDFSS) X +2.9° = -5.8 min
	+2°52'	

	1726	LST (Longitude corrected sunset)
minus	-6	(algebraic subtraction)
ANSWER	1732	LST (Sunset at Pakse)

To compute SUNRISE the same procedure is followed except that the Vientiane Sunrise and LDFSR will be used instead of the sunset and LDFSS. The morning twilight parameters (BMNT and BMCT) are computed using the same procedures as for SUNRISE: The evening twilight parameters (EECT and EENT) use the same procedures as for SUNSET.

Fig. 19.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Hq, Air Weather Service (MAC) Scott AFB, Illinois 62225

13. ABSTRACT In two parts. Part I is an annual discussion; Part II, a monthly discussion. Essentially based on previously available data, however, precipitation analyses and ceiling and visibility data are new. Part I has an introduction with geographical sketch, climatic outline with expanded statements on temperature, relative humidity, precipitation, cloudiness, winds; a regional discussion (mountains and Mekong lowlands); climatic conditions discussing general circulation, seasonal weather, air masses; geographic controls including effects of topography, continentality, oceans and latitude; special phenomena including local winds, floods and droughts, tornadoes, hail, duststorms, extratropical cyclones, fronts, tropical cyclones and convergence zones; and a weather elements section with detailed discussions of temperature, humidity, precipitation, cloudiness, thunderstorms, turbulence, hail, visibility, wind and aircraft icing. Part II monthly discussions contain a climatic brief followed by discussion on temperature, humidity, precipitation, thunderstorms, cloudiness, visibility, obstructions to vision, winds, temperatures aloft and combined ceiling/visibility. Contains a station locator and topography map showing major terrain features. Isoline analyses (map scale 1:5,000,000) are given for annual and monthly mean precipitation days, daily maximum and minimum temperatures (scale 1:9,000,000), and ceiling/visibility $\geq$5000/5 and $\geq$1000/2$\frac{1}{2}$ (07 and 16 LST). Annual and monthly tabular data for 5 stations for humidity (07, 13, and 19 LST), extreme precipitation data and thunderstorm days (10 stations), visibilities $<$ 1 and $<$ 5 miles (07 and 16 LST), and fog-haze/smoke (07 and 16 LST). Monthly sunrise, sunset, morning and evening twilight data are presented for Vientiane with method for adapting to other locations.

DD FORM 1473

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